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ANTHROPOMETRY

HRDLIČKA

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Received December 2, 1933.

ANTHROPOMETRY

BY

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PUBLISHED BY
THE WISTAR INSTITUTE OF ANATOMY AND BIOLOGY
PHILADELPHIA
1920

27510

SOM.
H858a
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Rec. Dec. 2, '33.

PRESS OF
THE NEW ERA PRINTING COMPANY
LANCASTER, PA.

TO

LEON MANOUVRIER

MY INSTRUCTOR IN ANTHROPOMETRY

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ANTHROPOMETRY

ALEŠ HRDLIČKA

INTRODUCTION

Definition: Anthropometry may perhaps be most simply and comprehensively defined as the conventional art or system of measuring the human body and its parts. The systems of measuring the skull and the skeleton are known separately as *craniometry* and *osteometry*, but these terms are frequently merged with that of anthropometry; thus we speak only of anthropometric instruments, anthropometric methods anthropometric laboratories.

Object: The object of anthropometry is to supplement visual observation, which is always more or less limited and uncertain, by accurate mechanical determinations. The ideal function of anthropometry would be the complete elimination of personal bias, and the furnishing of absolutely correct data on such dimensions of the body, organs, or skeleton, as might be of importance to those who are to use the measurements. This ideal is not attainable to a perfection, but it is the highest duty for every worker to strive for as close approach to it as may be in his power.

Diversity: Anthropometry in general is not and may never be one uniform system. It is a handmaid to various classes of workers who have different objects in view, and measurements that are indispensable to one may be of no concern to another.

Measurements of the body were begun and are used by the artisan, and by the artist, the object of the one being a proper "fit' and that of the other a correct or artistically superior production. They were and are employed in recruiting armies, with the aim of eliminating the inferiors. They are used to some extent by medical men and dentists, to assist them in reaching diagnosis or tracing improvement in their patients. They enter largely into the modern systems of college and other gymnastics, and lately also into those of the popular baby studies. Certain measurements play important rôle in criminological and medico-legal identification. Finally, we have measurements that have become invaluable aids to scientific research in physiology, anatomy and especially anthropology.

To summarize, measurements on the human body or its parts are practiced for:

1. Industrial purposes;
2. Regulation of art;
3. Military selection;
4. Medical, surgical, and dental purposes;
5. Detection of bodily defects and their correction in gymnastics;
6. Criminal and other identification;
7. Eugenic purposes; and for
8. Scientific investigation.

As a result of the multiple applications of body measurements, there have become differentiated, aside from the industrial and artistic systems which are of little interest to us in this connection, the military, criminological, and also clinical and eugenic anthropometry, besides that used for strictly scientific research and more particularly for anthropological purposes. As to the last named, were it not for the seeming alliteration of the two words, the term *Anthropological anthropometry* would be of real utility.

The diversity of measurements in the various above named branches of activities is a legitimate necessity. Regrettably, this diversity extends also more or less to instruments and methods, which makes a free interutilization of the obtained data difficult if not impossible. There is a great loss of effort, and even the most closely related of the above branches remain more or less strangers to each other. One of the foremost aims of all those interested in anthropometry in the broader sense should be a general unification of instruments and methods, as far as this may be practicable.

Anthropology: The present treatise is devoted to measurements used in anthropology. The aim of anthropological measurements is not to replace, but supplement visual and other observations, or give them more precision.

Variety of Measurements: There are none except natural limits to the number or variety of measurements that can be legitimately practiced on the human body or its remains. Moreover, every measurement or set of such, if carefully secured on sufficient numbers of individuals representing different human groups, will be of some value. But some of the measurements were early seen to be of greater general interest or importance than others, came into universal use, were properly regulated, and constitute to-day the anthropological SYSTEM OF ANTHROPOMETRY. This system, however, though rigid in essentials, has no definite limits, and is subject to such changes as may in the course of time be found advisable.

In the development of the system it was soon found that diversity of method was very prejudicial to progress, which led to attempts at regulation of the methods and instruments by schools, by national, and finally by international agreements. Unfortunately, the earlier agreements conflicted, in consequence of which a great deal of work was lost. Up to the Franco-Prussian war of 1870, the system of Broca or the French school was almost universal; after the war, however, the rapidly growing tendency in Germany for individualism did not spare anthropometry. In 1874 the first proposals in this direction were made by Prof. Ihering to the Congress of the German anthropological societies. In 1877 a Craniometric Conference was held on this subject at Munich, and still another took place in 1880 in Berlin. The outcome of the deliberations at these conferences was a scheme drawn up by Professors Kollman, Ranke, and Virchow, which was submitted for consideration to the 13th General Congress of the German Anthropological Society, held at Frankfort-on-Main in 1882. The scheme was adopted and designated as the "Frankfort Agreement."[1] It introduced new nomenclature and other modifications, with unfortunate results. Henceforth there were the "French School" and the "German School" of anthropometry. But the new system did not prevail and the need of an international unification of methods began to be felt.

One of the first attempts at an international unification of anthropometric measurements was made in the early 90's in Paris, by Dr. R. Collignon.[2] The effort was made in connection with certain anthropometric studies planned by him at that time, and consisted in his sending to various anthropologists of prominence in as well as outside of France certain propositions, with a request for their critique and opinion. The effort, while favored in France, remained that of an individual, and led to nothing definite.

A much more promising, yet in the end quite as fruitless effort for unification of anthropometric methods was made at the occasion of the Twelfth International Congress of Prehistoric Anthropology and Archeology, held in August of 1892, at Moscow. Two commissions were appointed for the purpose (see p. 6), but they accomplished nothing substantial. The interest in the subject was however well aroused by this time, and the anthropologists meeting in 1906 with the XIIIth International Congress of Prehistoric Anthropology and Archeology in Monaco, undertook seriously and in a large measure successfully the formation of an International Agreement on Anthropometry. The work thus auspiciously begun was continued by the anthropologists meeting with the XIVth Congress, in 1912, at Geneva. The task thus undertaken is not yet finished; but what has been done furnishes a sound and large nucleus for further developments. At the occasion of the XVIIIth International Congress of Americanists, at London, in 1912, foundations were laid for the formation of an international association of anthropologists,[1] and one of the essential features of such an association must be a permanent International Anthropometric Board, which will deal with all questions relating to the harmonization of anthropometric methods, instruments, and procedures.

---

[1] Garson, J. G. The Frankfort Craniometric Agreement, with Critical Remarks thereon. *J. Anthrop. Inst. Gr. Brit. & Ire.*, 1885, xiv, 64–83.

[2] Collignon, R. Project d'entente internationale au sujet des recherches anthropométriques dans les conseils de revision. *Bull. Soc. Anthrop. Paris*, 1892, xiii, 186–8.

The results in anthropometric unification thus far attained are embodied in two reports, published originally in French in 1906, and in the French, English and German in 1912. As these agreements are of fundamental importance to every worker in physical anthropology, and as they are not as readily available as desirable, they will be here republished. In translating the French report of 1906 there were found a number of points which needed a few words of explanation and this report, therefore, is annotated.

THE INTERNATIONAL AGREEMENT FOR THE UNIFICATION OF CRANIOMETRIC AND CEPHALOMETRIC MEASUREMENTS

Report of the Commission Appointed by the XIII International Congress of Prehistoric Anthropology and Archeology, at Monaco, 1906

By Dr. G. Papillault, Reporter of the Commission

Translated from Dr. Papillault's report in L'Anthropologie, 1906, XVII, 559–572, by A. H.

On the motion of MM. Hamy, Papillault and Verneau, the Organising Committee of the XIIIth International Congress of Prehistoric

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[1] See Marett, R. R. Report of an International Conference, etc. Proc. XVIIIth Intern. Cong. Amer., London, 1913, I, LXXXVI.

Anthropology and Archeology had included among the questions a consideration of which by the members of the Congress was regarded as of the greatest importance, the subject of unification of anthropological measurements.

At the opening session of the Congress, which took place at Monaco on the 16th day of April, 1906, Professor Hamy, as President, called attention to the urgent need of an international agreement on anthropometric technique. But he also called attention to the almost insurmountable difficulties which would be met with if the numerous measurements which had been employed to date were to be examined in the open session of the Congress, and to the consequent necessity, if satisfactory results were to be obtained, of appointing a Commission which would specially occupy itself with the subject during the time of the session and at the last meeting of the Congress present some project of unification for approval by the Congress.

This proposition was adopted, and the commission was named immediately, comprising the following:

Giuffrida-Ruggeri, Secretary of the Anthropological Society and Assistant to the Chair of Anthropology, Rome;

Hamy, Professor of Anthropology at the Museum of Natural History, and member of the Institute, Paris;

Hervé, Professor of Ethnology at the École d'Anthropologie, and former President of the Anthropological Society, Paris;

Lissauer, President of the Anthropological Society, Berlin;

von Luschan, Professor of Anthropology, University of Berlin;

Papillault, Assistant Director in the Laboratory of Anthropology of the École des Hautes-Études, and Professor at the École d'Anthropologie, Paris;

Pittard, Private Docent at the University of Geneva;

Pozzi, one of the Professors of the Faculty of Medicine and former president of the Anthropological Society, Paris;

Sergi, Professor of Anthropology and Director of the Anthropological Institute, Rome;

Verneau, Assistant to the Chair of Anthropology, at the Museum of Natural History and Temporary Professor at the École d'Anthropologie, Paris; and

Waldeyer, Professor of Anatomy, and permanent Secretary of the Academy of Sciences, Berlin.

The Commission met immediately after its nomination to elect its officers and arrange the program of its activities. Professor Waldeyer was chosen President, Professor Sergi Vice-President, and Dr. Papillault Secretary and Reporter.

Dr. Papillault read a letter which he had received from M. Chantre, in reply to the demand which he [Dr. Papillault] had made for his [M. Chantre's] report on the efforts for the unification of anthropological measurements undertaken by the International Congress of Anthropology of Moscow. The main part read as follows:

"I have been, in fact, charged with such a report at the Congress of Moscow for the Congress of Paris. But as the quest on [of unification of anthropological measurements] had not been made a part of the regular program at the Moscow meeting, Professor Virchow, Chairman of the International Commission of Craniometry, in accord with some of our colleagues, asked that the said report should not be presented until at the following [Paris] session."

In M. Chantre's report on anthropology at the Moscow congress, we read that two Commissions were named for the purpose of unifying anthropological measurements. They were:

1. *The Anthropometric Commission*, appointed following a communication by M. Zograff on "Anthropometric Methods as Practiced in Russia, and on the Necessity of Forming an International Agreement for Anthropometric Research." This commission was to "endeavor to unify as far as possible the methods of anthropometric observations," and to report at the next session. It was composed of MM. Anoutchine, Bogdanoff, Chantre, Kollman, Malieff, Sergi, Tikhomiroff, Virchow, and Zograff. M. Bogdanoff was elected its President and M. Zograff the Secretary and Reporter. The headquarters of the commission were with the Imperial Society of Natural Sciences and Anthropology of Moscow.

2. *The Craniometric Commission*. On the motion of Professor Kollman of Basle the Congress named also a commission to revise the Convention of Frankfort, with the object of securing for anthropology an international system of craniometric measurements. This commission consisted of MM. Anoutchine, Bogdanoff, Chantre, Kollman, Malieff, Sergi, Virchow, and Zograff. Professor Virchow was elected its President, Professor Anoutchine its Secretary-Reporter.

The letter from M. Chantre shows further that neither of these commissions has reached any appreciable results. The Anthropometric Commission, it seems, has never met; while the Craniometric Commission held only two meetings during the session of Moscow, without reaching any ageement.

M. Papillault insists on the necessity of the present Commission meeting at least twice a day during the entire session, in order to subject the various techniques actually employed in anthropometry to a serious revision and to reach an agreement. The matter is urgent. The Frankfort agreement has been abandoned by most of the German scientists themselves, and the French method is no longer uniform. At Paris the disciples of Broca retain perhaps the illusion of still following a uniform technique, but a little inquiry shows divergencies which render all comparison of the results of some of their measurements quite incorrect. The school of every country presents probably divergencies of method among its different members which equal and even exceed those that separate it from other schools. This simple statement should banish from our debates all motives that may be foreign to science. None of us would endeavor to defend a national tradition which has proved incapable of preserving a unity of doctrine, and such a tradition in fact exists no more. In its selection of a technique the commission should be guided solely by fitness, simplicity, precision, and the biological value of the various measurements.

On the motion of Professor Waldeyer the commission decided to limit its activities to the measurements of the head [and skull] which are so numerous as to claim all the time that might be at the disposal of the Commission. Every measurement which has gained even a limited usage, together with the principal variations in its technique, should be submitted by the Secretary for revision to the Commission. In every case where an agreement will be reached, the Secretary shall edit the definition and technique of the measurement in question between the sessions of the Commission, and submit the text for the approval of the latter.

The Commission terminated its work Saturday, April 21, and the Secretary announced to the Congress that the report was ready in a neighboring room where it could be freely consulted. At the same time he offered to give the members of the Congress whatever explanations might be found necessary. At the end of this day's session, the report in its final form was presented to the Congress by the President, and received a *unanimous approval*. It here follows:

PROJECT OF AN INTERNATIONAL AGREEMENT ON CRANIOMETRIC AND CEPHALOMETRIC MEASUREMENTS

Preliminary remarks: The Commission classed as *optional* certain measurements which appear interesting, but concerning which the

Commission does not possess sufficient details which would permit it to fully gauge their importance and advise their regular employment. In cases of this nature the Commission has contented itself with a statement concerning the technique of the respective measurements, without giving advice as to their use.

In connection with each measurement is given an indication as to the instrument which should be employed. The abbreviations are as follows:

c.g.—*compas glissière*, the sliding compass;

c.e.—*compas d'épaisseur*, the spreading compass;

m.t.—metric tape. This should be made of decidedly pliant material, but without possessing in the least degree the quality of stretching. Slightly starched cloth is of the best; and frequent testing of the tape by a metal standard is indispensable.

I. CRANIOMETRY

A. THE SKULL

1. *Maximum length of the skull or greatest antero-posterior diameter; c.e.*

This is the maximum glabello-occipital diameter of the vault.[1]

Landmarks: Anteriorly—the most prominent point of the glabella; posteriorly—the most prominent point on the occiput as shown by the maximum determinable spread of the branches of the compass.

2. *The Iniac antero-posterior diameter* (optional); *c.e.*

Taken in the sagittal and median plane of the vault.

Landmarks: Anteriorly—the most prominent point of the glabella; posteriorly—the inion, the individual peculiarities of which should be discounted.[2]

3. *The maximum breadth of the vault, or the greatest transverse diameter; c.e.*

This is the greatest horizontal and transverse diameter which can be found on the vault by the spreading compass.

Landmarks: Determined solely by the maximum breadth of the skull above the supra-mastoid and zygomatic crests.

---

[1] The French text reads: "C'est le plus grand diamètre dans le plan sagittal et médian du crâne." This definition is somewhat erroneous, for it seems to direct that the measurement be taken to a point in the median line of the skull, while a little further on this point is defined as "le point le plus saillant du sus-occipital donné par le maximum d'écartement des branches du compas." As a matter of fact the point of maximum distance from the glabella is seldom strictly in the median line of the occipital, even in absolutely normal specimens. The correct definition should read as given above. A. H.

[2] "dont les variétés individuelles devront être évitées."

4. *Heights of the vault:*

(*a*) *The basilo-bregmatic height; c.e.*

Landmarks: Inferiorly—the basion, or median point of the anterior border of the foramen magnum (avoiding the exostoses that are sometimes found at this place); superiorly—the bregma, or median point of the coronal suture.

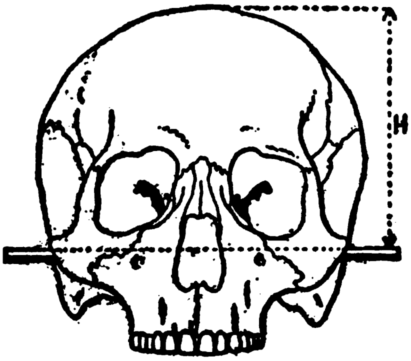

FIG. 1

(*b*) *Auriculo-bregmatic* height (*H*, fig. 1).[1]

This is the distance between the bregma and a line connecting the superior borders of the auditory meatus.

Landmarks: Inferiorly—the point where the imaginary line uniting the superior borders of the two *meatus auditorius* intersects the median part of the skull; superiorly—the bregma.

5. *The smallest frontal breadth or minimum frontal diameter, c.g.*

This is the shortest horizontal diameter between the two temporal crests on the frontal bone.

6. *The maximum frontal breadth or maximum frontal diameter; c.g.*

This is the largest horizontal diameter of the frontal squama (the bistephanic diameter of Broca is abandoned).

7. *Maximum bimastoideal diameter* (m.m. fig. 2); *c.e.*

Landmarks: The external surface of each mastoid process at the level of the center of the meatus auditorius. At this level search with the spreading compass for the maximum diameter.

8. *The maximum bizygomatic diameter; c.g.*

Landmarks: The most widely separated points on the external surface of the zygomatic arches. The object is to find the greatest diameter.

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[1] See p. 64.

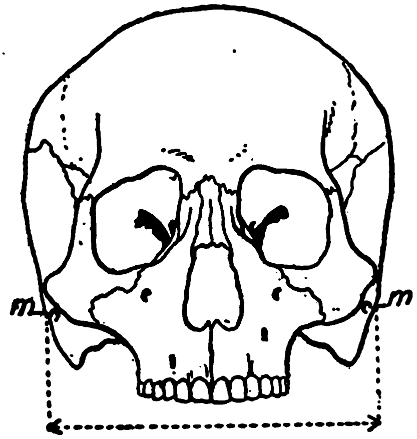

FIG. 2

9. *The naso-basilar diameter; c.e.*

Landmarks: Anteriorly—the nasion, or median point of the naso-frontal suture; posteriorly—the basion.

10. *The basio-alveolar diameter; c.g.*

Landmarks: Anteriorly—the alveolar point, or median point of the anterior border of the alveolar arch; posteriorly—the basion.

11. *The nasion-menton diameter; c.g.*

Landmarks: Above—the nasion; below—the inferior border of the lower jaw, in the median plane.

The mandibula to be in place, the jaws brought in apposition, the condition of the teeth [in relation to wear, especially] to be noted.

12. *The naso-alveolar diameter;*[3] *c.g.*

Landmarks: Superiorly—the nasion; inferiorly—the lowest point of the alveolar border between the two median upper incisors.

13. *Nasal height; c.g.* (N E fig. 3).

Landmarks: Superiorly—the nasion; inferiorly the middle of a line connecting the lowest points of the two nasal fossae.

If instead of the border there is a gutter, measure to the level of the floor of the nasal fossae [*i. e.*, to the upper limiting line of the gutters].

---

[3] The facial index is expressed by the following formula:

$$\frac{\text{Naso-alveolar diameter} \times 100}{\text{maximum bizygomatic diameter}}$$

14. *Breadth of the nasal cavity; c.g.*

Landmarks: The lateral borders of the nasal aperture. Find with the compass the greatest diameter of the aperture in horizontal line.

15. *Inter-orbital breadth; c.g.*

Landmarks: Bilaterally—the point where the posterior lacrymal crest meets the inferior border of the frontal.

16. *Orbital breadth.*

Landmarks: Mesially—the dacryon, or point of meeting of the sutures formed by the frontal, the lacrymal, and the ascending part of the superior maxillary bones;

(If the dacryon is obliterated, or in an abnormal situation, take the point where the posterior lacrymal crest meets the inferior broder of the frontal);

Distally—the external border of the orbit, at the point where the transverse axis of the orbit meets the border, and parallel as far as possible to the superior and inferior borders.

17. *Orbital height; c.g.*

Landmarks: The superior and inferior borders of the orbit, avoiding the superior and inferior notches, when they exist. Take the maximum distance between the two borders along an axis perpendicular to the preceding measurement [orbital breadth].

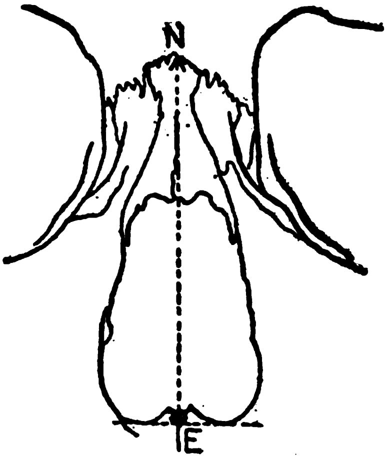

FIG. 3

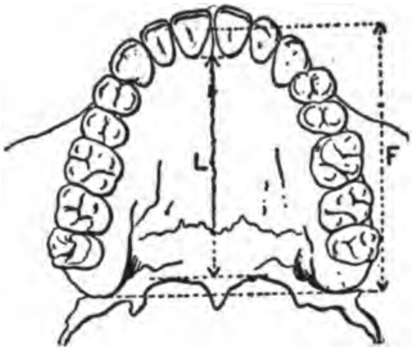

FIG. 4

18. (*a*) *Breadth of the upper alveolar border; c.g.*

Landmarks: The external surface of the alveolar border, on each side.

If there are any exostoses on the border they are to be avoided by placing the points of the instrument above the same. The measurement to be taken is the maximum transverse separation of the alveolar borders.

(*b*) *Length of the alveolar arch; c.g.* (F, fig. 4).

Landmarks: Anteriorly—the anterior surface of the alveolar border between the two median incisors; posteriorly—the middle of a transverse line connecting the posterior extremities of the alveolar border.

[This transverse line is obtained easily by placing a wire as deep as possible on each side in the notch which separates the alveolar border from the pterygoid process.][4]

19. *The bony palate: c.g.* (optional).

(*a*) *Length of the palate* (*L*, fig. 4).

Landmarks: Anteriorly—the median point of a line tangent to the posterior alveolar border of the median incisors; posteriorly—the median point of a transverse line connecting the most anterior points of the notches in the posterior border of the palate.

(*b*) *Breadth of the palate.*

Distance between the [internal] alveolar borders between the second molars.

20. *Orbito-alveolar height; c.g.* (optional).

The minimum distance between the lower border of the orbit and the alveolar border.

21. *Foramen magnum; c.g.*

(*a*) *Length.*

Landmarks: Anteriorly—the basion; posteriorly—the opisthion, or median point of the posterior border.

(*b*) *Breadth.*

Landmarks: Points of maximum separation, in transverse line, of the lateral borders of the foramen.

22. *Sagittal arc of the vault; m.t.*

Landmarks: Anteriorly—the nasion; posteriorly—the opisthion.

Intermediary: Apply tape to the surface of the vault along the sagittal line.

The arc is divisible into three principal parts which should be recorded separately and which correspond to the three bones composing the vault, namely the frontal, parietal and occipital.

---

[4] The maxillo-alveolar index will be:

$$\frac{\text{Maximum breadth of the alveolar border} \times 100}{\text{Length of the alveolar arch}}$$

[This subdivision is not seldom vitiated by the presence of intercallated bones, especially at lambda.]

23. *Transverse arc; m.t.*

Landmarks: Measure from the most prominent point on each zygomatic crest, directly above the meatus; the tape to be applied transversely over the vault in such a way that it will pass over the bregma and connect the two preceding points.

(*b*) *Circumference, or Horizontal Arc; m.t.*

Landmarks: Anteriorly—above the supraorbital ridges; posteriorly—over the upper portion of the occipital, so as to obtain the maximum measurement; care necessary that the level of the tape is the same on both sides.

24. *Capacity.*

Without making a selection from the different methods and while recognizing the value of the method of Broca, the commission advises that there should always be at hand standards or skulls of control, of considerably differing capacities, with which the exactness of the individual procedure should be verified; the commission also advises, however, the utilization as far as it may be possible of the direct measurement of cranial capacity by water with a rubber bag or container.

B. LOWER JAW

25. *Bicondylar breadth; c.g.*

Landmarks: The most external points on each condyle; the separation of these points constitutes the measurement.

26. *The bigoniac breadth; c.g.*

Landmarks: The gonions, or points of the angles formed by the ascending branches with the body of the lower jaw.

The separation of the angles is measured by applying the compass to their external surface.

27. *Length* [*i. e.*, height] *of the ascending branch; c.g.*

Landmarks: Superiorly—the uppermost point of the condyle;[5] inferiorly—the gonion; but as frequently it is very difficult to determine this point, it is best to take the intersection of the lines prolonging the inferior and posterior borders of the bone.

---

[5] The French original says "bord superieur du condyle," which doubtless means the transverse ridge of the condyle on which the uppermost point is generally located. See illustration.

The measurement is obtained by permitting the lower jaw to rest on its inferior border, and placing the rod of the sliding compass along the posterior border.

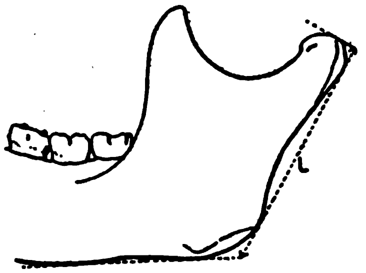

FIG. 5

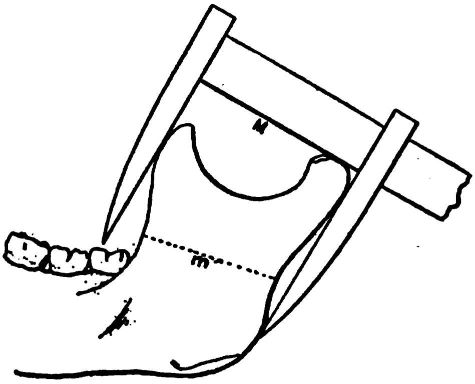

FIG. 6

28. *Breadth of the ascending ramus; c.g.*

(*a*) *Minimum breadth* (m, fig. 6): The minimum distance between the anterior and posterior borders of the ramus.

(*b*) *Maximum breadth* (M, fig. 6) (optional).

Landmarks: Anteriorly—the most prominent point on the anterior border of the coronoid process; posteriorly—the farthest point on the posterior border of the bone.[6]

The measurement is obtained by applying one of the branches of the sliding compass tangently to the posterior border of the lower jaw, and bringing the other branch in contact with the anterior border of the coronoid process.

29. *Height of the symphysis; c.g.*

Landmarks: In the median plane: superiorly—the highest point of the alveolar border [bet. the median incisors]; inferiorly—the inferior border of the symphysis.

Measure the actual distance between the two points, not in projection.

30. *Height of the body of the lower jaw; c.g.*

The same technique, but the measurement is taken in a vertical plane, between the first and the second molars.

---

[6] Really, as well seen from the illustration, the line connecting the most posterior point of the condyle and the point of the angle of the jaw. *Tr.*

31. *Maximum thickness of the body of the lower jaw* (optional).

The maximum separation of the internal and external surfaces of the bone in the plane between the first and second molars.

32. *Mandibular angle.*

The angle between the posterior and inferior borders of the bone. To be measured by Broca's *goniomètre* and according to the technique advised by that author.

II. CEPHALOMETRY

1. *Maximum length of the head,* or *the maximum antero-posterior diameter;*[7] *c.e.*

The same technique to be followed as on the skull; do not press.[8]

2. *The maximum breadth of the head or maximum lateral diameter; c.e.*

Same technique as on the skull.

3. *Height of the head* (head erect). Instrument: The anthropometric square.

Landmarks: Superiorly—the vertex; inferiorly—the superior border of the auditory opening, which ordinarily corresponds (but the point should always be verified) to the parts of the notch between the tragus and helix.[9]

4. *The minimum frontal breadth; c.e.*

Same technique as on the skull.

5. *Maximum bimastoidal diameter; c.e.*

Same technique as on the skull, the observer standing behind the subject.

6. *Maximum bizygomatic diameter; c.e.*

Same technique as on the skull. The maximum should be searched for with care, for it is often located more posteriorly than one would expect.

7. *Bigoniac diameter; c.e.*

Same technique as on the skeleton. The fleshy parts of the masseters are to be avoided.

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[7] In all measurements on the living taken with the spreading compass it is indispensable to search for the greatest spread of the branches, then fix the latter in their position with the screw and replace them over adjoining parts to verify if the spread has really been maximum. [If proper care be taken the awkward fixation of the branches by the screw is not necessary. *Tr.*]

[8] A moderate amount of pressure is of course necessary; the instruction is directed against hard pressure. *Tr.*

[9] The height from the middle of the line connecting the floor of the external auditory canals, to bregma is now more in vogue. See p. 64. *Tr.*

8. *Height of the face, total; c.g.* (optional).[10]

Landmarks: In median plane, superiorly—the hair line; inferiorly—the inferior border of the lower jaw. A slight pressure is to be used, to discount the soft parts.

9. *Menton-nasion diameter; c.g.*[1]

Same technique as on the skull, and using slight pressure, as with preceding measurement.

Look for the nasion by passing the nail along the ridge of the nose until it encounters a slight ridge which is formed by the inferior border of the frontal [or the depression of the nasion itself].

10. *The naso-buccal diameter; c.g.*

Landmarks in the median plane: Superiorly—the nasion; inferiorly—the line between the lips.

11. *The naso-alveolar diameter; c.g.*

Same technique as on the skull. It is always easily possible to turn the lips up so that the free border of the gums can be seen.

12. *Height of the nose; c.g.*

Landmarks: Superiorly—the nasion; inferiorly—the nasal septum where it joins the upper lip. Do not press.

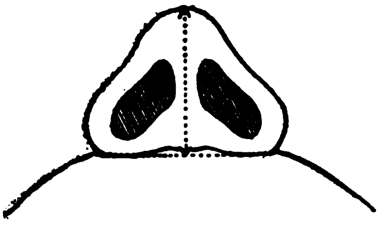

FIG. 7

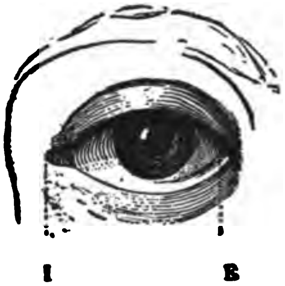

FIG. 8

13. *Breadth of the nose; c.g.*

Landmarks: The external surface of the alae of the nose. The maximum breadth to be determined without the exertion of any pressure.

14. *Prominence of the nose at its base* [*i. e.*, length or height of the septum] (fig. 7).

Landmarks: Anteriorly—the most prominent part of the point of the nose; posteriorly—the point where the septum is intersected by a transverse line joining the deepest points of the two naso-labial furrows.

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[10] Can be more readily taken with the spreading compass. *Tr.*

To take this distance the two landmarks should be well exposed [by bending the head well backward]; use instrument appropriate for the purpose.

15. *External bipalpebral breadth; c.g.* (*E*, fig. 8).

Landmarks: The external angle of each palpebral fissure, deeply, where the lines touch the eyeball.

With the eyes of the subject wide open and the visual axis fixed slightly above the horizon, the two points are approached by the branches of the compass supported on the cheeks of the subject.

16. *The internal palpebral breadth; c. g.* (*I*, fig. 8).

Landmarks: The internal angle of each eye, without regard to the caruncula.

17. *Breadth of the mouth; c.g.*

Landmarks: The commissures of the lips [angles of the mouth], at the point where the mucous membrane joins the skin. The distance to be taken while the mouth is in its medium position [*i. e.*, naturally closed without tension].

18. *Bilabial height; c.g.*

Landmarks: Superiorly—the uppermost points on the curves of the arc of the upper lip; inferiorly—the lowermost point on the curve of the lower lip.

The rod of the compass should be held vertically, its branches tangent to the summits of the curves.

19. *The ear.*[11]

(*a*) *Length, maximum; c.g.* (fig. 9, line designated).

Landmarks: Superiorly—the highest point on the border of the helix; inferiorly—the lowermost point on the lobule.

The rod of the compass should be held parallel to the long axis of the ear with its branches tangent to the points indicated; use no pressure.

(*b*) *Length of the cartilaginous ear* (fig. 8, interrupted line).

Landmarks: Above—as with preceding; below—the inferior border is the cartilaginous concha.

The compass is to be applied as in the preceding measurement, but the lobule is slightly pressed backward with the lower branch of the instrument, in order to include no more than the cartilaginous part.

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[11] Measurement of the left ear is to be preferred as much more handy than that fo the right. *Tr.*

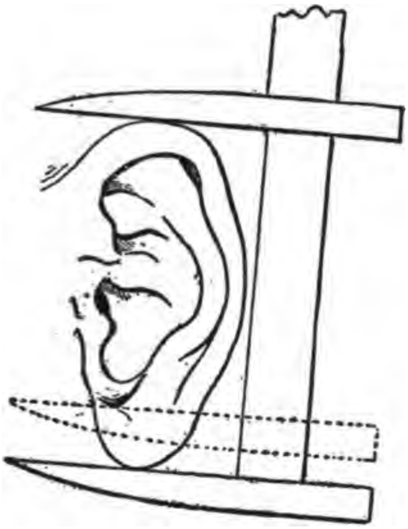

FIG. 9

(c) *Breadth.*

Distance between two lines parallel to the long axis of the ear, one of these lines being tangent to the anterior, the other to the posterior border of the helix.

The above outlined technique of each of the measurements was, after a discussion, unanimously adopted.

(Signed)
President, WALDEYER. Vice President, G. SERGI.
Members of the Commission: GIUFFRIDA RUGGERI; E. T. HAMY; G. HERVÉ; LISSAUER; VON LUSCHAN; PITTARD; POZZI; VERNEAU.
G. PAPILLAULT, Reporter.

THE INTERNATIONAL AGREEMENT FOR THE UNIFICATION OF ANTHROPOMETRIC MEASUREMENTS TO BE MADE ON THE LIVING SUBJECT

REPORT OF THE COMMISSION APPOINTED BY THE XIVTH INTERNATIONAL CONGRESS OF PREHISTORIC ANTHROPOLOGY AND ARCHAEOLOGY AT GENEVA (1912), TO SUPPLEMENT THE WORK COMMENCED BY THE XIIITH CONGRESS IN THE SESSION AT MONACO (1906)

ENGLISH TRANSLATION OF THE OFFICIAL VERSION[1]

W. L. H. DUCKWORTH, M.D., Sc.D.

(One of the three recorders appointed by the Commission)

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THE INTERNATIONAL AGREEMENT FOR THE UNIFICATION OF ANTHROPOMETRIC MEASUREMENTS TO BE MADE ON THE LIVING SUBJECT

I. INTRODUCTION

During the International Congress of Prehistoric Anthropology and Archeology, held at Geneva from the 9th to the 12th September, 1912, an International Commission was appointed in order to determine the unification of anthropological measurements to be made on the living subject. The meetings had thus as their object, that of supplementing the work accomplished during the Congress held at Monaco in 1906, when the unification of craniometric and cephalometric measurements was achieved.[2]

The Commission which met at Geneva included the following members of the Congress:

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[1] The Anthropplogical Laboratory of the University, New Museums, Cambridge. Oct. 30, 1912.

[2] International Congress of Prehistoric Anthropology and Archaeology, Session XIII, Monaco, 1906, Tome II, pp. 377–394.

Messrs. Chantre (France).
Czekanowski (Russia).
Duckworth (Great Britain).
Frassetto (Italy).
Giuffrida-Ruggeri (Italy).
Godin (France).
Hillebrand (Hungary).
Hoyos Sainz (Spain).
Hrdlička (United States).
Loth (Russian Poland).
von Luschan (Germany).
MacCurdy (United States).
Manouvrier (France).
Marett (Great Britain).
Mayet (France).
Mochi (Italy).
Musgrove (Great Britain).
Pittard (Switzerland).
Rivet (France).
Schlaginhaufen (Switzerland).
G. Sergi (Italy).
Sollas (Great Britain).
Volkov (Russia).
Weisgerber (France).

The Commission sat on four occasions, as follows:

Sep. 11.	8 a. m. to mid-day.	President: Professor Manouvrier.
Sep. 13.	8 a. m. to 11 a. m. 3 p. m. to 4 p. m.	President: Professor G. Sergi.
Sep. 14.	9 a. m. to 10 a. m.	President: Dr. Duckworth.

Messrs. Duckworth, Rivet and Schlaginhaufen were appointed recorders of the proceedings, and were instructed to prepare the report of the Commission.

The full report of the recorders was adopted unanimously by the Commission at the meeting on Sep. 14, and also by the Congress at the concluding meeting on the same day.

II. GENERAL PRINCIPLES

(*a*) The *erect position* is adopted as that which the living subject shall assume for the purposes of measurement.

(*b*) The ***method of projection*** is adopted in all cases save those in which special mention is made of a different method.

(*c*) For "***paired***" measurements, the ***left*** side is recommended; but measurements of both the right and left sides are to be made in the two cases following:

height of the acromion }
height of the great trochanter } above the ground.

(*d*) Observers are requested to indicate in every case, with precision, their method and the instruments employed.

(*e*) Those persons desirous of undertaking anthropometric work are very particularly urged to obtain preliminary ***practical*** instruction in a laboratory, and not to be content with a merely theoretical study of the various methods and processes of mensuration.

III. DETAILED DEFINITIONS OF THE MEASUREMENTS APPROVED BY THE COMMISSION AND THE CONGRESS

1. ***Stature:*** The subject stands erect on a horizontal and resisting plane surface (hereafter spoken of as "the ground"): no support is to be given by a vertical plane: the upper limbs are pendant, the palms of the hands turned inwards, and the fingers pointed vertically downwards, the heels in contact, and the axis of vision horizontal. The height of the vertex above the ground is to be measured in this position.

2. *[3]***Auditory canal:*** anatomical landmark (***point de repère***) the bottom of the notch between the tragus and the helix. (This point had been adopted previously at the Monaco Congress: cf. *op. cit.* p. 391.)

3. ****Chin:*** anatomical landmark: the inferior border of the mandible in the median plane.

4. ****Supra-sternal notch:*** anatomical landmark: the deepest point in the hollow of the notch.

5. ****Mammilla or Nipple:*** anatomical landmark: the center of the nipple. This measurement is not applicable to women with pendant breasts.

6. ****Umbilicus or Navel:*** anatomical landmark: the center of the umbilical cicatrix.

7. ****Pubes:*** anatomical landmark: the upper border of the symphysis pubis in the middle line. Where this point is impalpable, guidance

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[3] Measurements preceded by an asterisk, thus *, are those in which the subject retains the position already indicated for the measurement of the stature. [In making the measurements 2–8 and 10–18 inclusive the height of the "anatomical landmark" above the ground is to be determined. W. L. H. D.]

as to its position is given by the cutaneous fold of the lower part of the abdomen in this situation.

8. **Spinous process of the 5th lumbar vertebra:* to ascertain this anatomical landmark with exactitude, the subject shall be caused to bend forwards from the hips, when the spinous process of the 5th lumbar vertebra will become prominent.

9. *Sitting height:* the subject sits on a horizontal and resisting seat about 30 to 40 ctm. high (this height being proportionate to the stature of the subject): the knees are flexed: the dorsal aspect of the trunk is to make contact with a vertical plane, or with the anthropometric rod at two points, viz. in the sacral region and again between the shoulder-blades. The axis of vision is horizontal, as in No. 1 (*supra*). The height of the vertex above the surface of the seat is to be measured.

10. *Pelvic height:* the subject retains the position adopted for the sitting height (No. 9). The height of the summit of the iliac crest above the surface of the seat is to be measured.

11. **Acromion:* anatomical landmark: superior and external border of the acromion process.

12. **Great Trochanter:* anatomical landmark: upper border of the great trochanter.

13. **Anterior superior iliac spine:* anatomical landmark: the summit of the anterior superior spine of the ilium. In cases of difficulty, the point is found by tracing Poupart's ligament to its iliac termination which defines the point precisely.

14. **Elbow:* anatomical landmark: the radio-humeral articulation.

15. **Wrist:* anatomical landmark: the tip of the styloid process of the radius.

16. **Tip of the middle finger.*

17. **Knee:* anatomical landmark: upper border and edge of the inner tuberosity of the head of the tibia.

18. **Ankle:* anatomical landmark: tip of the internal malleolus.

19. *Span:* the subject is placed against a wall, the arms extended horizontally, the palms of the hands directed forwards. Measure the distance between the tips of the middle fingers of the two hands.

If a wall is not available, the rigid anthropometric rod is to be placed behind the subject, who assumes the position described in the preceding paragraph. The same measurement is to be made.

In either case, the *maximum* span of the subject is to be recorded.

20. **Bi-acromial diameter:* maximum distance between the two acromial points (cf. No. 11).

21. **Bi-humeral diameter:* maximum distance between the two prominences formed by the deltoid muscles. Secondary measurement.[4]

22. **Bi-mammillary diameter:* distance between the two nipple-points (cf. note appended to No. 5). Secondary measurement.

23. **Bi-cristal diameter:* maximum distance between the external margins of the iliac crests. In making this measurement, the observer is to direct the arms of the sliding compass obliquely downwards, and from before backwards.

24. **Bi-spinal diameter:* measured between the two anterior superior iliac spines (cf. No. 13 *supra*).

25. **Bi-trochanteric diameter:* maximum distance between the external surfaces of the great trochanters. In making this measurement the superficial tissues are to be strongly compressed.

26. **External conjugate* (*antero-posterior*) *diameter of the pelvis:* anatomical landmarks: in front, the superior margin of the symphysis pubis in the middle line: posteriorly, the tip of the spinous process of the fifth lumbar vertebra.

27.[5] **Transverse diameter of the thorax* (No. 1). This measurement is to be made in the horizontal plane at the level of the base of the ensiform cartilage. The observer is to record the mean of the measurements taken at the extremes of inspiration and of expiration respectively: alternatively, the measurement may be made in the intermediate stage as regards those two phases of respiration.

28. **Transverse diameter of the thorax* (No. 2). This measurement is to be made in the horizontal plane at the level of the upper border of the fourth chondro-sternal articulation. The same observation (as to the phases of respiration) applied here as to No. 27 *q.v.* Secondary measurement.

29. **Antero-posterior diameter of the thorax* (No. 1). This measurement is to be made in the same horizontal plane as is defined in the case of the transverse diameter of the thorax No. 1 (cf. No. 27). The same observation (as to the phases of respiration) applies to this measurement as to No. 27 *q.v.*

30. **Antero-posterior diameter of the thorax* (No. 2). This measurement is to be made in the same plane as is defined in the case of the transverse diameter of the thorax No. 2 (cf. No. 28). The same

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[4] A certain number of measurements are thus described in accordance with the instructions of the Commission.

[5] In making measurements Nos. 27 to 30 inclusive, care is to be taken that the extremities of the calliper-arms are wide, since with the ordinary pointed arms there is a danger of error owing to the points slipping on to an intercostal space.

observation (as regards the phases of respiration) applies to this measurement as to No. 27 *q.v.* Secondary measurement.

31. **Sternal height:* measured with sliding callipers: from the suprasternal notch (cf. No. 4 *supra*) in its deepest part, to the base of the ensiform cartilage.

32. *Bi-condylar diameter of the humerus.* Secondary measurement.

33. *Bi-styloid diameter of the fore-arm.* Secondary measurement.

34. *Bi-condylar diameter of the femur.* Secondary measurement.

35. *Bi-malleolar diameter.* Secondary measurement.

36. **Thoracic circumference:* this circumference is to be measured in the horizontal plane, passing through the base of the ensiform cartilage. The same observation applies here as to No. 27. Secondary measurement.

37. *Circumference of the neck.* Secondary measurement.

38. *Circumference of the upper arm.* The maximum circumference obtained *below* the insertion of the deltoid muscle, the arm being held in the position of rest.

39. *Circumference of the upper arm* with the biceps muscle in the contracted state. Proceed as in the case of No. 38. Secondary measurement.

40. *Maximum circumference of the fore-arm.* This measurement is to be made in the region of the epitrochlear and epicondylar muscles and extensors, *i. e.*, immediately below the joint-level.

41. *Minimum circumference of the fore-arm.* This measurement is to be made above the level of the styloid processes of the radius and ulna.

42. *Maximum circumference of the thigh.* This measurement is to be made at the level of the gluteal fold.

43. *Minimum circumference of the thigh:* measured above the level of the knee-joint.

44. *Circumference of the calf of the leg:* the maximum value.

45. *Minimum circumference of the leg.* This measurement is to be made above the level of the malleoli.

46. *Minimum circumference of the waist.* This measurement is to be made at the level of the most constricted portion of the abdomen.

47. *Contour of the hand.* The right hand is applied to a sheet of paper, the fingers being very slightly separated, and the axis of the middle-finger forming a prolongation of that of the fore-arm. The two ends of the bi-styloid line are to be marked by pencil dots. Starting from these points the contour of the palm and fingers is to be traced

with a pencil split longitudinally and held vertically. Special dots are to be added, marking (*a*) the extreme ends of the interdigital clefts, and (*b*) on each side, the position of the metacarpo-phalangeal articulations.

48. *Contour of the foot.* The right foot rests on a sheet of paper, the leg being perpendicular to the plane of this surface. Draw four short lines to mark the positions of the ends of the malleoli, and of the metatarso-phalangeal articulation of each side. Then the contour of the foot is to be traced in the same way as described for the hand (cf. No. 47). The extreme end of each interdigital cleft is to be marked by a dot. It is useless to trace the inner border of the foot between the malleolar point and the metatarso-phalangeal point, for this part of the tracing is always unreliable.

49. *Height of the plantar arch.* The foot being placed in the position requisite for tracing its contour (cf. No. 48), the vertical distance is to be measured between the plane of support and the upper border of the navicular bone. Secondary measurement.

IV.

The Commission and the Congress also adopted unanimously the following proposal and resolutions:

(*a*) *For the reconstruction of the stature from observations on the long bones of the skeleton.*

For the reconstruction of the stature with the aid of the long bones, the maximum length shall be measured in all cases save in those of the femur which is to be measured in the oblique position, and the tibia which is also to be measured in the oblique position, the spine being excluded.

(*b*) The Commission wishes to state that it is desirable that in the graphic representation of cranial forms, either the plane of Broca or of the Frankfort Agreement should be employed by anthropologists.

(*c*) The Commission holds that it is desirable that anthropologists should append complete lists of measurements to their publications.

(*Signed*) W. L. H. DUCKWORTH
(*One of the Recorders of the International Commission*).

PRELIMINARIES

I

Some day it may be possible to deal with the actual state of anthropometry in general, and with the many individual modifications of and tendencies in the same which are outside of international agreements; but what the American student of the branch needs most are simple, practical, well tested instructions for his guidance in work which is rapidly increasing. An active interest in the various lines of research which fall within the scope of physical anthropology is rising everywhere, as witnessed by the increasingly frequent calls at our laboratories from different parts of the country for instruments help and directions, by the number and calibre of our visitors, and in the unprecedented demand for trained anthropologists.

These conditions were brought about partly by the war, which offered suddenly such great opportunities for applied as well as research anthropometry; partly by the intensification of the problems of immigration, Americanization, and conservation of child life, which are receiving a steadily increased attention; and partly by a gradually augmenting institutional demand for instruction and work in anthropology. These rapidly developing demands found anthropology unprepared to give much material help. There were few available trained men and others could not be produced in a short time. There was no adequate supply of instruments, with curtailed or lost facilities for having these made. And there was nothing in English in the way of publications that would give the indispensable information as to methods, technique and other essential aspects of anthropometric procedure on modern lines.

The results of this state of affairs, aggravated by various complications, were that anthropometric research in connection with the U. S. Army has been a failure; that even the most important places in anthropology could not be filled; and that in the absence of something better a large amount of present anthropometric work on children and older subjects is carried on with the instruments and the methods of the gymnasia and physical culture establishments rather than those of classical anthropometry, with the consequence that practically all this work is lost to science and even tends to create prejudice against anthropometry in general.

Evidently enough it is imperative for those who have the interests of physical anthropology in this country at heart to mend conditions as rapidly as may be possible, and one of the first and most urgently desirable steps is to furnish legitimate, readily utilizable instructions in scientific anthropometry. It was with this end in view that the AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY published the International Agreements on Anthropometry, the most binding of all of our instructions. But these alone are not sufficient. They are in certain respects incomplete and somewhat too curt. Moreover, they do not deal with descriptive characteristics and, while forming a necessary nucleus, are not all that the student wants and needs. Some good instructions in English for taking measurements and observations are to be found in the "Notes and Queries on Anthropology" of the British Association for the Advancement of Science, but the subject there is not dealt with as much in detail as desirable. The American student in anthropology, and in growing measure also the American medical investigator, asks for a readily available, as simple as possible and yet sufficiently comprehensive, strictly modern, and thoroughly correct treatise on anthropometry.

The question is how and how far these demands may be met under the present circumstances. Were American anthropologists more numerous, the best way would doubtless be for them to undertake the important task jointly and impersonally. As conditions are, however, it appears that the first steps must be individual; and in taking the same the author does so only because his extensive field as well as laboratory experience in this line gives hope that something serviceable may be accomplished. His work has been based throughout on the methods of the École d'Anthropologie in Paris and on the so far effected international agreements, with only such additions or modifications as experience on different races, classes, and ages of people and on their skeletal remains has shown to be necessary or advisable.

The procedures, instruments, etc., to be here described, are those in regular use at the Division of Physical Anthropology, U. S. National Museum and in field work for the same. They are also, in the main, in use at Harvard and elsewhere, and form the basis of instruction given to the students who apply for that purpose at the National Museum.

II

Two of the main lessons taught by experience in anthropometry are, the need of precision, and the value of simplicity. Precision is a matter of proper well tested instruments, of good instruction, and of that something in the nature of the investigator, whether inherent or built up, which strives for accuracy and abhors looseness. Simplicity is the open road to advance. The road that is clogged by a multitude of unnecessary measurements and digressions leads generally to stagnation.

It is self-evident that in a branch of research where so much depends on accurate measurements, the objects of first importance are the *instruments.* The instruments should be accurate and not easily disordered; they should be in the highest degree well-balanced and "handy" or easy of manipulation, as well as of reading; they should be free from qualities that in the long run might in any way bias the determinations; and they should be easily transportable for field work. Finally their cost should not be prohibitive.

Before the war we had such instruments. The best were those made on the original patterns of Broca, the father of anthropometry, or, with useful modifications, by Collin and Mathieu in Paris; but nice sets were also made in Switzerland. During and since the war the supply of French instruments has ceased, with the resumption uncertain, while the Swiss instruments have advanced considerably in price and are not readily obtainable. Also they retain the disadvantage of a small "compas d'épaisseur," one that does not permit the measurement of the height of the head which has become of much importance. The American instrument makers could not as yet be prevailed upon to undertake the manufacture of anthropometric instruments at reasonable price. We are therefore confronted with difficulties that cannot be readily surmounted. As a result anthropometric work has already been considerably interfered with in this country and on numerous occasions the instruments used are the less adapted and less accurate ones used for gymnastic or other purposes.

With proper instruments, the next absolute necessity in scientific anthropometry is proper *instruction.* This point was strongly insisted upon during the conference of the International Committee on Unification of Anthropometric Procedures at Geneva (1912), and becomes more pressing as time goes on. A person who is a medical graduate, or is used to the manipulation of other instruments of precision, is not yet thereby fitted to practice anthropometry. He could conceivably develop, by much reading and long practice, an efficient system of his own, but only with much loss of time and many errors. The work of self-instructed and insufficiently instructed observers has filled the earlier anthropological literature with reports in which no one is able to place full confidence, and such work has served to retard rather than favor progress, as well as to create much undeserved prejudice as to the value of anthropometry.

Today a would-be anthropologist who is not known to have received competent instruction in the generally approved methods of the science, finds it hard to publish his results in professional periodicals and hard to have it accepted by first class institutions; his efforts, in fact, are often lost and he ends by becoming discouraged.

Anthropometry deals with such a variety of conditions, and often with so small differences of proportions, that of necessity it must be reduced to a rigid system, which, while not beyond attainment from mere reading and practice, is much more readily and satisfactorily imparted to the student at a well-recognized anthropometric laboratory. Such laboratories are now available in this country as well as in France and England, besides other countries.

With proper instruments and proper instruction, and unyielding sense of honesty, the worker in anthropometry must develop a habit of minute care and accuracy, until these become automatic. Some students appear to be incapable of acquiring these habits in sufficiently effective form, and such students should give up anthropometry. In a few the needed qualities are inborn and need only a direction; but in most they must be developed. It is fortunate that the most careful and accurate work brings the most pleasure, and is the best sustainer. The student who gets tired of measuring the human form or even the skeleton, is the one who has not been careful and accurate to the limit of his possibilities.

Accuracy and endless care do not, of course, mean absolute perfection—only its highest attainable degree. Our instruments will never be so accurate or senses so precise, and our subjects or specimens will never offer such forms, that an absolute precision may be obtained. Time and again the student on repeating a most carefully made measurement, will find a slight difference, an experience which at first may be discouraging. But with the careful and well trained observer such differences remain immaterial and never develop into unconscious bias in any direction, as they are very likely to do with the less well trained or less strict worker.

The first law of anthropometry being *precision*, the second is that of *simplicity*.

The goal of rational anthropometry is the greatest possible simplicity of procedure in measurements, in the treatment of data, in publication. A profusion of measurements marks the beginner, the amateur, the absorbed impractical teacher. The experienced, clear-sighted observer will be seen to take only such measurements and observations as will most help him to describe a given people, or bring out the salient points on a collection of specimens. He has two golden rules in this connection which he follows—first, to attempt no measurements on the living which can be more easily and accurately secured on the skeleton; and second, to include no more measurements on any occasion than can be secured on the largest obtainable number of subjects or specimens.

It is self-evident that there can be little use of spending valuable time in trying to take measurements on the living for which the landmarks are uncertain or which call for resented exposures, so long as we may obtain skeletal remains of the people in question on which the problems involved may be studied with greater facility; and it would be a poor anthropological procedure which would give preference of the number of measurements to the number of subjects to be examined. The number of measurements and observations may safely be said to be as a rule subordinate to the number of subjects studied, and to interests of prompt elaboration and publication of the data.

The treatment and analysis of the secured data are naturally procedures of the greatest importance, for on them will depend, next to the accuracy of the data, the value of the report to be published.

Due to the nature of anthropological measurements and observations, their treatment must be in part mathematical and in part biological, but both of these methods are capable of unnecessary complexities. Given a completed series of trustworthy data, the objects of the student naturally will be, first, to extract out of these data their full anthropological value; and second, to present these results in the most scientific and at the same time assimilable form to the forum of his fellow anthropologists. All this calls again essentially for solidity and simplicity. The publications should be free from "unfinished business" and perplexing formulæ. They must not be an extension of the laboratory blackboard or scrap-paper. The calculations and analyses, whatever their nature may be, are parts of the preparation of the material, and except in explanatory notes ought not to constitute a part of the final report. No calculation in anthropometry is so abstruse that it could not be presented in the final report in plain terms, freely and unequivocably intelligible to all workers in the branch, and to other intelligent readers. Whenever a doubt arises in the mind of a conscientious worker as to what method of analysis or special presentation would be preferable—and there will be not a few of such cases—his best guides will be the relative usefulness of the procedure, and the simplicity of presentation.

Most of these points will be dealt with further on special occasions.

III

The best and in fact the only sufficient *preparation* for scientific anthropometry, are the studies which lead to the degree of doctor of medicine. In fault of such complete courses there should be at least equivalent courses in anatomy, physiology and pathology. Being the comparative science of man, physical anthropology and its handmaid anthropometry deal with the whole range of human variation, which, while essentially structural and functional, is at every step modified or modifiable by pathological conditions. The student with a simple A.B. or Ph.D. without the special courses here mentioned, has a great and often insurmountable disadvantage for a career in physical anthropology even though he was able to receive legitimate instruction in the latter and training in anthropometry. He will remain a bird with a paralyzed wing.

Besides a suitable scientific foundation the worker-to-be in anthropometry should possess a good reading knowledge, in addition to English, of the French and German languages, at least, for the bulk of anthropological literature is still in those languages and there are very few translations. He should further possess good training in drawing as well as in photography. Moreover, if he is to make anthropology and anthropometry his life vocation he must also possess certain physical qualifications. He must have good, enduring eyesight; and large capacity for work both in the field and in the laboratory. Last but not least, he should possess those mental qualities which will enable him to follow his work with undimmed enthusiasm and vigor under smaller material compensation and perhaps other advantages than those of his friends who have remained in medical practice or chosen other vocations; for anthropology is not an industrial necessity. The compensations for this lie in the high grade of his work. He deals intimately with the highest of organisms, he contributes to the knowledge of what is most worth while. His studies of human evolution and antiquity, of the developing child and youth, of the infinite variation of full-blown manhood and womanhood, of the laws that control all this, and of the means by which these laws may consciously and effectively be directed for future advance of humanity—all these will provide him with mental food of such an order that he will easily forget the regrets of not having chosen a more remunerative vocation.

IV

Granted a well qualified student presents himself at our Laboratory for a thorough instruction in anthropometry, what will be the procedure? The preliminaries may be outlined as follows:

1. *Acquaintance with Instruments.*—Anthropometry commands a number of special instruments, which in exactly the same form are used in no other branch of science. These instruments are graduated in the metric system, which must be well understood by the scholar. They are all graduated in centimeters and millimeters, and this indicates the most natural and safest way of recording the data. Their marking, however, presents certain differences and peculiarities which must be thoroughly mastered, or they will lead to errors. Therefore the first lesson and practice will relate to a thorough acquaintance with the most common instruments; while the next will be devoted to their handling.

2. The *handling of instruments* is a matter of considerable concern. They may be handled uncouthly, and in such a way that they will tire the hand and eyes, even if not conducing to errors; and they may be handled so that they completely cease to be sensed as something foreign in the hand or to the eye, and offer not the slightest impediment to work however prolonged. Even in anthropometric laboratories and text-books, however, the methods practiced or advocated are not the same throughout, wherefore the student will need a careful guidance. An interesting fact in this connection is that all hands, short or long, stout or slender, are not equally adapted to any method and will generally result in more or less individual modification in the direction of least resistance. Also a long practice with a method that in itself is not the very best may lead to fair efficiency, which with personal reasons explains why more than one method are being perpetuated.

Attention to Instruments.—Anthropometric instruments demand a certain amount of careful attention, especially on expeditions. They should be well nickeled, to prevent rusting. They must work smoothly but not loosely. The joints and slide boxes should be kept slightly oiled, but so as not to soil the fingers of the operator. All the instruments should be periodically tested on standards, which gives the worker due confidence. If a thermometer is used it should be an instrument with plainly legible scale and one which will without fail give the maximum record within five minutes. Rapid thermometers are not especially advantageous, they break more readily, being made of thinner glass. To keep the thermometer clean a small bottle of peroxide or other antiseptic is provided, in which the instrument is kept between use. A towel or two should be kept on hand to clean the instruments as desirable in the course of the procedure. Finally, due attention must be given the instruments in connection with storage in the laboratory between examinations, and in connection with transportation. They should have a suitable glass-door case in the laboratory, and a specially made portable box or case for outside and field work.

3. A *study of landmarks* should logically be the next step. Measurements, to be strictly comparable, must be taken in a strictly defined way and from or between the same anatomical points. These points, whether on the living or on the skeletal parts are known as the anthropometric landmarks, with which the student must become thoroughly acquainted. To facilitate this he should begin with the most needed points on a good series of dry skulls of both sexes and widely differing ages where he may learn their exact location, significance and variation. An additional skull of a young and one of adult anthropoid ape, particularly the chimpanzee, are very useful in this connection.

From dry material but with this still at hand, the student will pass to the determination of the needed landmarks on living male adults, then on females and finally on children. He should invariably now and even later mark some of the points with an aniline pencil, which will facilitate his measurements.

4. In the actual *practice of measuring*, it is necessary to impress the student with the necessity of concentration of his attention on the subject or specimen within his hands and on the scale of his instrument; the holding and handling of the instrument will rapidly become automatic. With subject in convenient position, the landmarks determined, and the instruments properly used, everything depends on the accuracy of reading of the scale. More and larger errors probably are

committed in reading the scale in a poor light, by defective eyes, on instruments the scale markings of which have become dulled, and by carelessness, than through all other agencies. One of the best rules at this period is to make a double reading of each determination, and after having finished and made records, to repeat all the measurements. Nothing at this stage teaches as effectively as errors self-detected.

V

Principles of Recording. Blanks.—Every definite piece of anthropometric research calls for a well reasoned out and organized scheme. The student should be fully conscious of what he wants to ascertain. The objects of any given piece of work are such and such, and to attain them it will be most useful, or indispensable, to take such and such measurements and observations. For the records of these measurements and observations are arranged blanks on which they are placed in the order of their importance, relation and best practical sequence. Each blank is made so that it will serve, say, for twenty-five cases (two giving us 50, four 100), and is then printed or otherwise multiplied in sufficient numbers for the study at hand. A good blank facilitates greatly the whole procedure of measuring and observation, as well as the subsequent reduction of the data.

The size of the blanks is of considerable importance. The individual blanks for work on adults should not be larger than standard letter size paper (roughly 21.5 x 27 cm. or 8½ x 10½ in.). For all extensive work they should be printed. For a regular piece of anthropometric research more than one form will be required, and the separate forms should be marked with consecutive numbers or letters. Each blank bears an appropriate heading; is subdivided by seven horizontal lines so as to afford space for the legends, for the measurements of 25 subjects, and a space below where the summaries of the measurements or observations may be recorded. Each blank bears also a series of vertical lines for the records of the individual measurements or observations. The width of the resulting columns is regulated by the needs in each case, and should be ample enough to permit the making of plainly legible records without crowding. In the case of visual observations the records are of necessity and with advantage made by abbreviations. The left margin of each blank bears two perforations for binding. For a definite piece of work from four to six blanks of each number, sufficient for 100 to 150 individuals, are bound or clasped in loose-leaf covers, and each set is separated by a blotter.

This gives a very convenient "record-book," which is easily handled during the examination, whether this is carried on in field or laboratory, which is very convenient during the work on the data, and which can not be readily lost or mislaid. Illustrations of blanks will be given later.

Subjects of only one group, one sex and one stage of life are recorded on one blank, to save copying. The measurements are recorded in centimeters and their decimals, as they are marked on the instruments. To make the record in millimeters or meters, according to the essentially German method, has the disadvantages of a greater liability to error, and of a much greater difficulty of grasping and remembering the values of the measurements. The examiner records the figures himself to further guard against error; and until his mind is so trained that it can safely retain two successive determinations, he records each measurement by itself. A constant care is exercised to make each figure so that it will not be possible to mistake it for anything else; this applies particularly to 0 and 6, 4 and 9, 1 and 7, which if written hastily may readily resemble and be mistaken for each other. The recording is done invariably in pen and with permanent ink that will not fade out in the course of years, for some of the records secured may be of value long afterwards.

Although there would be no objection to a contrary practice, it is customary and doubtless more convenient as well as time saving, to proceed in the examination and hence on the blanks first with the measurements and then with the visual observations.

In choosing a *place for examination*, it is imperative to select the best lighted spot, and at the same time one where the observer will be least subject to interruptions. Side-light is undesirable; and measuring or examining in poor light or in artificial light, except perhaps strong electric arc light, is to be avoided unless dictated by absolute necessity. No conversation with the subject or a third person should be carried on during the examination, in order that the whole attention of the observer may be concentrated on the work itself. Finally, while it is not necessary to put down on the blank each measurement separately, not more than two consecutive measurements should be carried in mind before recording them. In the examination of women it is important to retain the attitude of the methodic, abstract investigator.

If the above rules are followed, the well-trained, earnest observer will find his work reduced to a mechanical procedure of high order, which will not tire him either mentally or physically and the precision of which will be a source of constant gratification.

VI

Selection of Subjects.—In the study of any human group the value of the data—all other things being equal—will be directly proportionate to the purity of the group. With this point in view the first steps of the observer will be directed towards a proper selection. Selection by sex, age, homogeneity, pathological conditions, and occasionally also according to occupation, social status, and environmental distinctions.

As an invariable rule, each sex is to be recorded on separate blanks, and in the case of children and adolescents the same is also true of each age group.

Subjects.—In work among the living, and particularly in field work among primitive tribes, one of the main concerns of the student is to obtain a sufficient number of good subjects. In order to do so he generally must have some help. Conditions will differ in this respect according to the group studied. In the case of schools, institutions, and recruiting stations, matters may be easily arranged. But when groups or tribes where submission to measurements can only be voluntary, are to be studied, the investigator must secure assistance. Among our own people much can be done by the observer making known as widely as possible the objects of his work and his needs; by interesting helpful friends in the work; and by engaging one or more active individuals who will assist him for a compensation. Among primitive tribes the best policy is, in the first place, to bring influential introductions; in the second place, to acquaint the chiefs and elders honestly and plainly with the objects of the work as far as they may comprehend; and by engaging, for a compensation, the best available men and women of the tribe to bring subjects. The compensation is best arranged at so much per subject, and as a rule it is also advisable to make a regular small payment to each subject. In explaining the objects of anthropometric work to primitive men and women it is best to dwell on the medical side of the examination, *i.e.*, the desire to ascertain the state of health and strength in the tribe with the diseases and causes of death, matters which they readily understand and appreciate. It is hardly necessary to add that the success of the student in anthropometry, with civilized as well as with primitive peoples, will depend in the main on his address and general behaviour. The honest, friendly and able worker, with earnest, dignified procedure, will have little difficulty in succeeding among any class of people.

Grouping by Age.—This will be guided by precedence and what may be called the scientific sense. It may differ somewhat according to the number of available subjects. In series of ample size, the segregation up to 6 weeks of age should be by weeks, from that on up to 1 year, by months. From 1 and up to 3½ years, by half a year; and thereafter by the year. The months and years are counted in such a way that "6 months," for instance, will embrace everything from 5 months and 16 days to 6 months and 15 days, while "6 years" will include all subjects from 5½ to 6½ years.[1] The grouping of small series of subjects is difficult, but the standard scheme should be followed as far as practicable. In especially important small series it is advisable to give the exact ages. The adopted system of grouping must, of course, always be clearly outlined in the report on the observations.

It is safe to include young men from 20 and young women from 18 years onward among adults, provided these subjects are not represented disproportionately in the series examined. It would not be proper, however, to take a class of such sub-adults, especially males, as fully equivalent to the full-growns of the same racial or social group, particularly in stature, chest, and few other measurements.

In a similar way individuals from 60 to 70 years of age should not be included in a general series if represented by a larger relative number than that by which they are represented in the general population. If more are available, they should be placed in a series of their own; and this precaution should be invariably followed with those above 70. The reason for separating the old is that various features and proportions have altered and continue to alter to the end of their life. These comprise the nose, ears, jaws, chest, stature and other parts. The only dimensions that are not appreciably altered in senility are those of the head, with the length of the limbs, hands and feet, and pelvic dimensions.

Estimation of Age.—So long as the student deals with Whites only, there will be little difficulty about ascertaining the ages of his subjects; but among more primitive peoples records of age are seldom kept and the observer will have to take a recourse to estimates. The value of such estimates will be directly proportionate to the care with which they are made and the experience of the one making them in that direction. They are least reliable in childhood, and again in old age. In arriving at his conclusion the observer is guided by the general development and appearance of the subject; by the eruption of certain teeth, particularly the permanent molars; by marks of puberty and climacterium; and by signs of aging such as grayness, wrinkling, bending of the spine, loss and wear of the teeth, absorption of the jaws, changes in sight and hearing, arcus senilis, clubbing of the fingers, etc. But it must be borne in mind that none of these signs individually, nor even in combination, can be taken as precise indices of age in years. They develop at widely different ages in different individuals, and even in the same person the setting in of the different signs of ageing may be very irregular. Thus, grayness may occur even in young adults, and the same is true of certain changes in the eyes and ears. Moreover they do not appear synchronously or equally in the cultured whites and other races. The student must be guided by the sum of the manifestations, supplemented by the subject's behaviour and by such indirect information (references to certain well known events, etc.) as may be obtainable. But even thus and with ample experience he cannot hope for closer approximation to the right age than within five years, plus or minus, among adults. For anthropometric purposes, however, such an approximation will be quite sufficient.

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[1] This method is preferable to that which would include under the "6 years" all subjects between 6 and 7. The mean of such a group would be 6½ years.

Admixture of Blood.—Admixture of blood is of two main kinds: (1) That between individuals of different tribes or other groups of the same race; and (2) That between individuals of different races. In general the latter is the more important, and every effort must be made by the investigator to detect individuals who bear such mixture and exclude them from his series. This applies particularly when we deal with mixtures of the three great stocks of mankind, namely the Whites, the Yellow-browns, and the Blacks (Negro and Negrito). For the sake of greater accuracy it would be well to speak of these great groups always as "stocks" or "strains," reserving the term "races" for the primary groups within these stocks—such as for instance the Nordics, Alpines, and the Mediterraneans among the Europeans.

The progeny of mixtures between individuals within the same stock are often unrecognizable and cannot be separated except on the basis of their family history. The progeny of mixtures of individuals belonging to different stocks are in general easier to recognize, but this facility differs according to the stocks concerned, for these are not all anthropologically equidistant. Thus the Whites and the Yellow-browns (including native Americans) are more closely related, than the Negro or the Negrito is with either one of these two strains, and their mixtures will be correspondingly more difficult to separate. Nevertheless with experience, care and certain tests such a separation may be said to be always possible where the mixture is one half and one half, and nearly always where it is one fourth and three fourths; but when the proportion of the blood of one of the component races is less than one fourth, the identification of the mixed-blood becomes frequently a matter of considerable difficulty and in mixtures other than those of the negro and white may be impossible. The estimate of the exact amount of particular blood in a given mix-breed is always more or less a matter of conjecture.

The criteria which guide us in diagnosing mixed-bloods, are the physiognomy, the color of the skin, the character of the hair, the color of the eyes and the tinge of the mucous membranes. Features such as the mongolic fold of the upper eyelid, shovel-shaped (deeply concave) upper incisors, marked freckles, etc., may be additional helps in individual cases, particularly in mixtures of Whites and Yellow-browns. The color of the skin should be observed on the usually covered parts of the chest.

Skin Tests for Mixed-Bloods.—On the pectoral parts of the chest may also be made certain tests developed by the author which in many instances of doubtful mixtures between Whites and Indians or other Yellow-browns, and between Whites and other colored races, will help us to arrive at a conclusion. They are tests for the blood reaction of the skin. In a full-blood individual of the Yellow-brown or other dark races, if the chest is exposed and the observer makes three or four vertical lines over the pectoral parts by drawing his finger nail over the skin with a certain amount of pressure, there will be little or no visible reaction; but if there is any mixture with Whites the lines will show as fairly broad red marks, and the flush will be of some duration—both features being the more marked the more white blood is present in the individual under examination, provided he is in the ordinary state of health. In malarial, anaemic and phthisical subjects, where the condition and supply of blood are much altered, the value of this test does not hold good.

The exact paternal or maternal *parentage* may in some cases be determinable through heritage of special features; but the need for such identification arises only in special instances.

Pathological Conditions.—In examining any group for purely anthropological purposes, it is obviously desirable to avoid the inclusion of any individuals who may have been affected by some pathological condition sufficiently to suffer a material alteration in their measurements. It is in this connection that practical knowledge of human pathology by the observer becomes necessary.

The disease that is responsible for most of the alterations that constitute sufficient reason for the elimination of the subject from our series, is rachitis. The evidence of this morbid process may exist in more or less deformed limbs, in pitted or eroded-like teeth, deformities of the thorax, ribs and pelvis, in various asymmetries, and in cranial deformations due to premature occlusion of some part of the sutures. Generally we find more than one of these defects in the same person. Markedly bowed legs, deformed thorax, or badly deformed pelvis, are sufficient reasons for excluding the subject from the examination.

Other pathological processes the results of which will often unfit the subject for anthropometric studies, are tuberculosis of the bones and joints, and various forms of paralysis. The former lead to deformities of the spine and of individual limbs, while the latter may affect directly and indirectly the whole body. The head and face in these cases may of course be unaffected and utilizable for our observations, but unless we can in addition get also a normal stature, it is better to exclude the individual.

In addition to the above the observer will meet with persons of defective constitution due to hereditary syphilis or other causes; and on the other hand he may find individuals in whom the body, the head, the facial parts, or individual limbs or features, may be overgrown (acromegaly, giantism), under-developed (dwarfing, cretinism), or seriously altered by other pathological conditions (congenital defects of individual parts or limbs, gross anomalies, microcephaly, hydrocephalus, arthritic lesions, wounds and fractures). The rule in such cases is, that wherever the condition or deformity is such that normal measurements and observations cannot be secured, the subject is not to be used for anthropological purposes. But if the deformity applies merely to one limb or part, this part alone needs to be excluded.

Cranial Deformations.—Cranial deformations, of whatever origin, are of especial importance to anthropometry, particularly as even in cases of skulls, where they are much more easily distinguished, they are known to have been included with or taken for normal variations.

The *pathological deformations* of the vault most commonly met with are *scaphocephaly*, where the vault is abnormally prolonged and the sagittal region resembles more or less the keel of a boat. This deformity, which may be accompanied by an annular retrocoronal depression, is due to premature occlusion of the sagittal suture. It is particularly common among the American negroes. Another form is *acrocephaly*, or abnormal increase in the height of the fore part of the vault, due in the main to premature occlusion of parts of the coronal suture. Still another frequent deformation which, however, does not except in pronounced cases necessitate the elimination of the subject, is *plagiocephaly*, or asymmetry of the vault, produced mostly by a premature occlusion of the coronal or lamboid suture on one side. In these cases we will find one side of the forehead to protrude more forward and the opposite side of the occiput to protrude more backward than the other side, besides which there may be differences in the parietal regions. In minor cases of plagiocephaly, however, the principal measurements of the vault are not perceptibly altered and there is no need to eliminate the subject. The cause of the condition in these minor cases is frequently obscure.

Posthumous deformations of the skull are met with occasionally. They may be localized or diffuse, the latter being generally lateral or bilateral. They may or may not be attended by warping or fractures. The more important grades are easily diagnosed. The specimens must of course be eliminated for all the measurements that are affected.

Artificial Deformations.—Besides the above, the student will meet more or less frequently, according to the people he is working among, with head deformations produced by artificial means. These are divisible into *non-intentional* and *intentional.* The non-intentional kind are as a rule produced in early infancy by the head of the infant lying habitually in a certain position on a resistant cushion. They consist of occipital or occipito-parietal flattening, which may be median or lateral, slight, medium or pronounced.

Intentional artificial deformations, which are particularly common in certain parts of this continent and among certain Pacific Islanders, are designed shapings of the head of the new-born infant, as a result of a habitual or religious observance. They are produced by the continued application of direct pressure, by board and pad, bandage and pads, or by a bandage alone, to the head of the new-born. They are of three main classes, namely, fronto-occipital (flat-head), circumferential ("macrocephalous" or "Aymara"), and occipital.

The "flat-heads" are characterized by a greater or lesser flattening of the front, a corresponding flattening of the occiput, a compensatory bulging of the parietal regions, a more or less marked depression along and just posterior to the coronal suture, and occasionally a more or less marked depression along the posterior portions of the sagittal suture. When pronounced, the last named condition gives rise to the so-called bilobed crania.

The "Aymara" deformations are characterized by a more or less marked, broad, circular flattening or depression passing over the frontal bone, the temporal squammae and the lower parts of the parietals, and over the lower portion of the occipital, while the posterior and superior portion of the parietals and the upper part of the occipital protrude in a compensatory way upward and backward. Anterior to the coronal suture in these cases there is generally an elevation, while posterior to the suture we find a more or less pronounced annular depression.

The occipital deformations resemble those produced accidentally, but in general are more marked. They may represent merely a favored and perhaps assisted incidental flattening due to the resistant head cushion, as among the Navahos and Pueblos; or they may occur, due to less effective methods, as by-products of the flat-head deformation with help of bandages, as among the old Peruvians. These deformations generally involve parts of the parietals, and may be median or lateral. They result in shortening, elevation and broadening of the vault, and in making the forehead both higher and more vertical.

Each of the above forms of head deformation presents a number of sub-varieties according to local differences in methods. And in all the deformation, if marked, affects the base, the orbits and the facial parts of the skull. Except in the minimum cases the changes in the cranial characteristics are such that the utilization of such individuals or specimens for anthropological research on the head or skull becomes very difficult, risky and often impossible. All these cases must be carefully excluded so far as measurements of the affected parts go.

Individual instances of small degree deformations of either class may, as already said, be readily mistaken for individual normal conformation, or pass undetected. The subject calls for special attention with each individual, which will be discussed more closely under "Methods."

VII

Photography and Cast-making.—In anthropological investigation, whether among primitive or civilized peoples, it is often highly desirable and may be necessary, in addition to measurements and observations, to take photographs also, and to make facial casts. Directions for these will be given later. In this place it may merely be stated that both photography and casting may well and with advantage be attended to by the observer himself. Nothing is more gratifying and, it may well be added, trouble saving, than one's own good work in these directions. The photographing should be done preferably, if conditions permit, immediately after the measurements and observations on the subject are concluded, for he may not be available at another time. It may even be necessary to take the cast at this time also for the subject has occasionally come from a long distance; but for those who may readily be reached the casting may be postponed until after all the anthropometric work is concluded.

VIII

FIELD ANTHROPOMETRY

The preceding introductory considerations may be rounded up by a few remarks as to anthropometry in the field, where conditions will differ radically from those in the laboratory.

Supplies; Transportation.—In general it is best to secure all the supplies for the scientific work of an expedition before departure, and to secure only the best and freshest materials. This applies particularly to plaster-of-paris for facial casts, and to photographic plates and films. The number and variety of articles to be carried along on an expedition cannot be given in detail. It depends largely on the regions to be visited, the prospective length of the expedition, and the experience as well as the wants of the observer. The best rule is to take everything needed, with nothing superfluous.

The cameras and instruments should be well tested before the trip. The paster-of-paris under ordinary conditions is carried in large tin cans or zinc lined boxes, and the photographic plates and films in their ordinary receptacles. For the tropics all such material should be carried in special light metal boxes, and in the case of the plaster every precaution must be taken against its becoming spoiled by moisture. The photographic necessities should be such as to permit under any circumstances the loading of plates and some test developments of exposures. A complete development of the plates and films and printing in the field are not advisable, unless the work is carried on in connection with some well established archeological or other exploring station.

An important item never to be neglected in connection with an expedition to primitive tribes is to take along an ample supply of small change, which is invariably rare in out-of-the-way regions; and the money should preferably be in used coin which will not be regarded with suspicion.

Cameras.—It is best to carry two cameras—a pocket kodak for scenes on the road and instantaneous exposures; and a larger camera, preferably with glass plates, for portrait work and larger landscapes. Both cameras should be provided with the best lenses obtainable, and be well tried out in every way before departure. A stereoscopic camera is advantageous.

Boxes.—The cameras, instruments, medical supplies and other articles are carried in standard canvas-covered boxes, with rounded corners and rope handles. These boxes should be of such a size that they may be conveniently carried on the backs of men, burros, horses, mules, llamas or camels, as well as in a railroad car or a wagon. They should be made of strong, light wood, preferably gum, well jointed, and have all the hinges on the inside to make robbery difficult. The best way of fastening is with strong padlocks. The size of the boxes found most convenient by the writer (except for the instrument case which should fit these) is, externally, height 18 in. (46 cm.), breadth 20.5 in. (52 cm.) and antero-posteriorly 14 in. (36 cm.). In field these boxes will serve various useful purposes, such as chairs and tables, and at night as a wind break, or base over which in case of rain may be spread a sheet of canvas converting the whole into a sort of shelter or tent; while on the return voyage they may be used to transport casts, photographic plates and specimens. In places where the examinations are carried on the boxes may again serve as chairs and tables; and if there are enough of them, at night they make a very good elevated bank on which to spread one's bed. By suitable inside partitioning one of these boxes may be fitted for medical supplies, one for kitchen utensils, one for the cast-making outfit, another for the photographic apparatus, still another for trinkets and smoking supplies for the natives, etc. The boxes are numbered or otherwise marked so that any desired one may be readily found when needed; and a duplicate set of keys is provided for a case of loss.

Companions.—This is a matter of much more consequence than might at first appear. In general the most satisfactory procedure is for the observer to engage only such companions as he may need in traveling from place to place. The taking along of friends, co-workers, or even a photographer, not only risks their exposure to sickness and greatly increases the expenses, but is often productive of much friction as to plans, food, time of starting, etc. It may further lead to difficulties in fixing blame for accidents and especially of credit for discoveries; and will frequently be productive of delays and inconveniences, for often where one can find what he needs, two or three cannot be accommodated. Free hand, freedom from anxiety for others, undivided responsibility, and undivided credit, are precious assets which should be carefully guarded by the explorer.

Miscellaneous.—Photographing and even measuring may have to be done by the roadside, in the field, or under other untoward circumstances which often will call for the exercise of not a little ingenuity. He may at first be received with suspicion and suffer for the faults of others. But with a fair interpreter, friendly, honest attitude, and such small gifts as may best be fitted to the occasion, the student will as a rule secure the needed observations. It is almost needless to say that his own health and strength will demand rational attention, for he will travel in and out of season, may have to endure exertions and privations, and be subject to infection through contaminated water, spoiled food, insects, and contact with diseased persons. All this can in a large measure be counteracted, and if so the field expeditions become to the worker not only a source of priceless experiences and acquisitions, but also of a deep recuperation.

ANTHROPOMETRY ON THE LIVING.—INSTRUMENTS

The *instruments* used in measurements on the living, with the exceptions of the compasses and the tape, are different from those used in measuring skeletal material. Also, there is not yet as complete uniformity in these instruments as might be desirable. Matters of this nature in all branches of science are largely those of evolution and the eventual survival of the fittest.

Most of the anthropometric instruments or their prototypes owe their development to the pioneers of the École d'Anthropologie, Paris, and more particularly to Paul Broca, the first director of the École and the father of anthropometry. The ingenuity and great service of Broca in this regard have not yet received a due appreciation. The instruments are partly non-metallic and partly metallic, partly fixed and partly free, and in some instances they differ somewhat according to whether they are to be used in the laboratory or in the field.

The instruments essential for measurements on the living are the planes or rods for measuring the stature, sitting height and the span; the spreading and the sliding compasses or calipers, for measuring the head, the facial parts and the hands; the large sliding compass for measuring the diameters of the chest, pelvis and feet; the anthropometric tape for measuring circumferences of the head, body and limbs; and certain accessories such as the dynamometer, color scales etc. They may briefly be described as follows:

1. *The Anthropometric Plane of Broca.*—Made of thoroughly seasoned wood, 1 meter high, 12.5 cm. broad, 1.5 cm. in thickness, stained dull yellow, varnished; graduated in centimeters full across, in half-centimeters one-half or two-thirds across, and in millimeters along the left or both margins. Marking plain, easily legible. The upper edge provided with two eye-screws or other device for hanging; and the plane may be hinged at the 70 or 75 cm. mark for easier transportation (A. H.). 1*a*. *Square* (Adjunct).—Two pieces of light wood, 18 cm. long by 12 broad by 1.2 in thickness, joined at right angles, and provided on the inside, in the middle line, with a narrow strip serving as a handle; stained and varnished as 1.

Use: for measuring stature and sitting height. In the laboratory it is of some advantage to use a separate plane for each of the two measurements, the plane for measuring stature being fastened one meter above the floor, while that for measuring sitting height is fastened directly above the bench on which the subject sits for this measurement. In the field, one plane fastened one meter above the floor or a level piece of ground, will do for both measurements, the height of the bench in the case of sitting height being subtracted from the total measurement obtained.

Modifications.—In the original planes of Broca, at a distance of 1 cm. from the left border, there was a fairly deep groove, which served for a graduated sliding square by which one could measure the stature as well as the ear and shoulder heights, and, together with another appliance, also the facial angle; all these have now become obsolete.

Paper or Cloth Plane or Tape.—At the occasion of certain recommendations made by the Committee on Anthropology of the National Research Council, in connection with the impending measuring of large numbers of recruits for the United States Army, the author proposed[1] that instead of the more costly plane, special inextensible linen or paper strips be printed to take its place. A strip of this nature, 8 to 12 cm. broad, printed accurately on inextensible and unshrinkable paper or other material (ordinary materials change considerably!), is easy to work with and has the advantage of cheapness as well as ease of transportation. They may be made in segments of 50 cm. In cases of necessity a scale may be improvised on the wall or other vertical, or on a strip of paper; or the ordinary anthropometric tape may be fastened to the wall, rod, etc. An improvised stout paper scale should be well varnished on both sides, to prevent puckering, shrinking or extension. All scales must be tested by standards.

2. *Anthropometer.*—A number of related instruments are embraced under this name. Their common principle is that of a graduated rod, single or in sections, fixed to a pedestal or with a free lower end, and provided with a sliding horizontal branch. They are used for measuring stature and sitting height, instead of the above described plane, and are particularly advocated for work in regions where no vertical such as a wall or tree may be found on which the plane might be fastened.

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[1] Am. J. Phys. Anthrop., 1918, i, 81.

The most useful modifications of this instrument are the *Anthropomètre* and the *Toise anthropométrique* of Topinard,[1] and the metal rod of Martin. The terminal part of the last named has both a fixed and a sliding branch and may serve for the purposes of both the anthropometer and a large sliding compass.[2]

These instruments are of value and continue to be employed by various investigators, particularly those of the Zurich school; but they are not as handy, easy of manipulation or accurate as the fixed plane. Moreover, there is a rather important difference in their mode of employment by the different observers, some using them in the same way as the plane, which secures a standard posture of the subject, while the followers of Martin place them in front of the subject, which makes the regulation of posture uncertain.

The writer advocates the use of the plane, for the fastening of which one can always find or provide some vertical.

Individuals met with on the road, in the fields, etc., may be measured against any suitable object and the height determined by the ordinary tape.

3. *Horizontal Plane* (Accessory).—For laboratory purposes and for field work where numerous subjects are to be measured, this is a useful accessory facilitating the measurement of the span. It consists of a light wooden plank, or paper strip, 30 cm. broad by 60 cm. in length, graduated from 140 to 200 cm. For the purposes of measuring the span a vertical wooden strip is fastened on the wall 80 cm. from and parallel with the left edge of the vertical plane, to serve as a "point d'appui" of the longest finger of the right hand of the subject. The horizontal plane is then fastened to the wall at a distance of 140 cm. from this vertical strip (or 47.5 cm. to the right of the vertical plane), and serves for the determination of the span length, the exact manner of taking which will be described under "Methods." A serviceable scale of this nature may be improvised on the wall. A paper scale must be well varnished.

4. *Wooden Bench* (Accessory).—For measuring height sitting (and other purposes). For laboratory use and in measurements on American people (who on the average are tallest of all Whites), the most serviceable bench is one of 50 cm. in height, 50 cm. in breadth, and 32

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[1] Élém. d'Anthrop. gén., 8°, Paris, 1885, 1116–20. Made by both Mathieu and Collin, Paris.

[2] Made by P. Hermann, Zurich.

cm. antero-posteriorly. For work among shorter peoples, and especially among children, the bench must be lower, the aim being for the thighs of the subject to be flexed at right angles to the trunk. In the field, any convenient well-made box may be used.

The laboratory bench is stained light mahogany or other suitable color, and varnished. It should be made of well seasoned wood, to prevent appreciable changes in particularly dry or damp weather.

5. *Plumb and Level* (Accessory).—When using an anthropometer, various measurements on the body, such as the sternal height, shoulder height, etc., may be taken direct, but unless the subject stands against some vertical there are always chances of error owing to uncertainty as to correctness of position. When using the Broca plane we may get all these measurements in a simple and more accurate way with the help of a small level and plumb. The level is made in the laboratory. It consists of a narrow glass tube, 16 cm. long, filled with alcohol containing a small bubble of air, and marked with a red ring at the middle. The plumb is a pointed piece of lead or other metal, suspended on a strong linen or silk thread. The subject stands against the plane in the same position as for the determination of stature; the level is applied to the landmark from which the measurement is to be taken, and held there horizontally by the left hand; the plumb is then dropped to the floor, without any slack, and the thread is pinched by the thumb nail and forefinger at the height of the lower edge of the level. The subject then steps aside, and the measurement taken is ascertained on the scale of the plane. The procedure is quite simple.

6. *The Spreading Calipers* (*Compas d'épaisseur*).—This is one of the indispensable and most useful instruments in Anthropometry. It is manufactured in several varieties. These are, (1) the small compass of Broca, made by Collin in Paris, as well as—with slight modifications—by Hermann in Zurich; (2) the standard larger compass of the Paris École d'Anthropologie, made for many years before the war by Mathieu as well as by Collin, in Paris; (3) the Bertillon compass, made by Collin; and (4) the Hrdlička compass made in France (Collin) and United States (Fig. 10).

The several instruments differ in usefulness. The small compass is more adapted for work on the skull than for that on the living, although it is also used for the latter purpose. The larger standard compass is an excellent instrument for ordinary anthropometric work on the living, as well as that on the skull. The Bertillon compass is

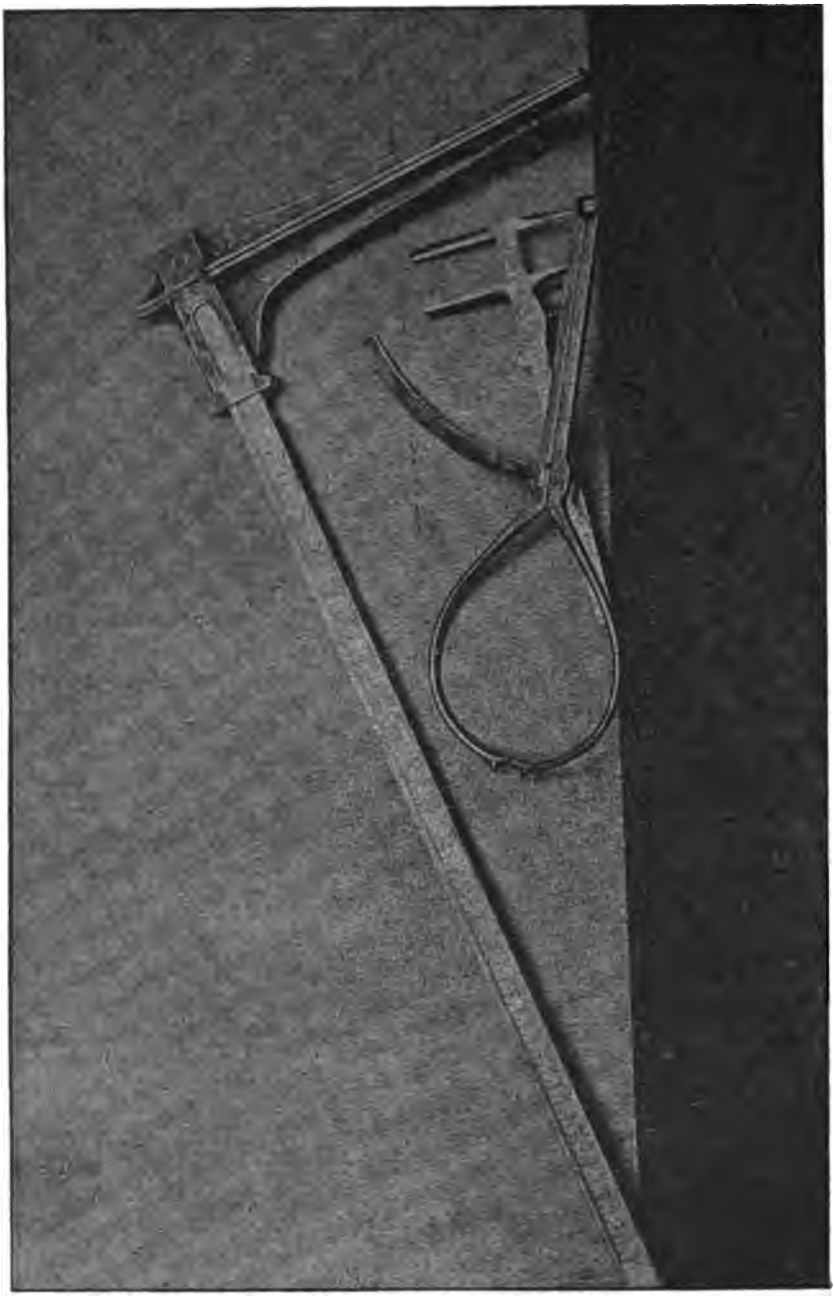

FIG. 10. The Anthropological Compasses. U. S. National Museum.

practically the same as the preceding, but is marked by a greater rigidity as well as bluntness of the branches, and a reduction of the scale. The Hrdlička compass possesses certain adaptations and needs a special description. Of the three older forms of calipers only one, the standard compass of Mathieu, could be used in measuring the height of the head. This measurement is one of growing importance and various methods as well as instruments have been devised in the past for securing it on the living. One of the easiest of methods, for many years practised by the author, was to introduce the branches of the standard compass into the auditory meatus, bring the scale of the instrument over the bregma, note the spread, determine with the rod of the sliding compass the distance from the bregma to the lower edge of the scale, and by a simple arithmetic procedure, obtain the height of the head. But these older instruments had certain disadvantages when used for this purpose, which were a somewhat inadequate size of the branches in the cases of large heads, an oblique direction of the terminal parts of the branches, particularly when sufficiently dilated for introduction into the ears, and the facility with which the branches penetrated deeper into the ear than required. To obviate these disadvantages, the writer in 1912 visited MM. Collin in Paris and gave directions for making compasses with slightly larger branches, with the terminal parts horizontal at the spread of 10 cm.; and with a guard on the lower portion of each branch 8 mm. from the point, to regulate the distance of introduction into the meatus. The resulting instrument is but imperceptibly heavier than the older standard compass of Mathieu; it serves with equal facility the same purposes; and in addition it is thoroughly well adapted for measuring the height of the head.

7. *The Sliding Compass* (*Compas glissière*).—This instrument is too well known to need special description. Figure (10) shows the compass of Collin, which is almost identical with that of Mathieu and is a well-balanced and most useful instrument. The Martin sliding compass shows slight differences, which appear to be matters of personal choice rather than those of additional usefulness.

8. *Large Sliding Compass.*—There are several instruments of this nature, some made of wood (Paris, American), others of wood with steel branches (Topinard, Manouvrier), and still others wholly of metal (Martin, Hrdlička). Except the wooden and the author's instrument, they have in common the disadvantage of narrow branches, which in measuring the thorax are liable to be pressed into the inter-

costal spaces; and not seldom, especially in the wooden compasses, the branches are not rigid enough, which results in some error of measurement.

The writer's instrument consists of a hollow rod, 70 cm. long, 2.2 cm. broad and 0.8 cm. thick, made of well nickeled and welded brass strips; and of aluminum branches, 26 cm. long (in the free) and 3.5 cm. broad. It is light, very serviceable, as well as durable, easy working, and accurate (fig. 10).

9. *Tapes.*—The best anthropometric tapes are made in Paris by instrument makers who stand in connection with the École d'Anthropologie. They are made of linen, painted grayish-white, are accurate and non-elastic. The layer of paint and varnish on each side is light and does not crack. One of these tapes gives months to years of service.

Steel tapes are easier to obtain but less advantageous. They are not so easy to manipulate and read; they are cold and sometimes they break. The steel tape may be used, however, with some advantages on skulls and bones.

10. *Standard Meter* (Accessory).—A strong lamina of brass, 1 meter long, graduated in centimeters and millimeters, standardized in France. Obtainable through the French manufacturers of anthropometric instruments. Very useful for testing accuracy of tapes and graduated planes. A laboratory instrument.

11. *Standard Block* (Accessory).—Block of wood or preferably metal, aluminum or brass, for testing the accuracy of calipers, at 5, 10, 15, and 20 cm. spread. The best appliances of this nature are made of metal. They are laboratory accessories.

12. *Dynamometer* (Collin or Mathieu).—Description unnecessary. No handles requisite for ordinary tests.

Other dynamometers are made, particularly in England and in the United States, but the results obtained by these are not strictly comparable with those obtained by the classic French instruments, and the latter are to be preferred on account of their simplicity, long use in anthropometry, and their handiness.

13. *Weighing Scales.*—The question of weighing scales in Anthropometry is one of considerable difficulty, for in general they are heavy and difficult if not impossible of transportation. In the United States and in England, moreover, we have practically no metric scales and must use those of the old system, which necessitates a subsequent conversion of the figures. Suitable weighing scales for infants in

both the old and the metric system are obtainable in Europe as well as in this country, but even these are heavy for transportation. Fortunately, weight in adults, on account of its great variation, is not a measurement of prime importance.

14. *Standards for Colors of Skin, Eyes, Hair* (Accessories).—Though generally satisfactory observations on skin, eye and hair color are possible without the use of standard color scales, the difficulties of nomenclature and of uniform instruction in different laboratories, have nevertheless caused a strong desire for a series of standards with which the colors found could be matched, and by the number or name of which they could be recorded. The result has been the preparation, by various workers, of scales of colors intended to facilitate this important part of anthropological observation. None of these scales represents all that could be wished for, but all have their uses.

Skin Colors.—There are several scales for matching skin color. The best known and one that has been most used is that of Broca,[1] the others being those of von Luschan,[2] Rudolf Martin,[3] and Gustav Fritsch.[4] Also there are other methods,[5] among them direct painting in the field of the shades observed, a procedure which meets with only limited success on account of the changes in the color of the pigments during drying.

Until an international agreement on some one scale is reached, the observer may use either of those now in existence, it being understood that in his report he will state which one he employed. Or he may use simple descriptive terms which will be given under "Methods" and which in most cases are quite sufficient.

Color Standards for Eyes and Hair.—The color of the eyes and the hair, as that of the skin, may be determined by unaided observation, and with many primitive tribes in general the task is quite simple.

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[1] Printed originally in his "Instructions générales pour les recherches Anthropologiques," *Mém. Soc. d'Anthrop.* Paris, 1864, II; 2e éd., 16mo., Paris, 1879; repr. on larger scale in Hrdlička (A.)—Directions for collecting information and specimens for physical anthropology, Bull. U. S. Nat. Mus., Pt. R. No. 39, Wash., 1904; also, in part and with different numbers, in the "Notes and Queries on Anthropology," of the B. A. A. S.

[2] v. Luschan's scale consisting of a series of colored glass tablets, is made by Hermann, Zurich.

[3] Mentioned by G. Fritsch.

[4] Fritsch's colors, on painted paper strips, may be had from W. Pfund, Berlin; the method is described in the *Mitt. Anthrop. Ges.* Wien, 1916, XVI, 183–5.

[5] Gray (J.), A new instrument for determining the color of the hair, eyes and skin (Man, 1908, VIII, 54); the Bradley's color top; the trade color scales; etc.

But among mixed groups, and particularly very mixed Whites such as the Americans, these procedures become more difficult and call for careful instruction as well as experience, or for the use of adequate standards. Such standards exist both for the eyes and the hair.

For the eyes there are several color scales, such as that of Broca,[1] Bertillon,[2] the Medical Department U. S. A.,[3] etc. In addition we have the artificial eyes of commerce, the glass eye standards of Galton,[4] and the "Augenfarbentafel" of Martin.[5] For hair, samples of actual human hair have been used (f. e. by Pearson—*Biometrica,* 1907, v, 474); and since 1907 we possess the good though still not fully sufficient artificial-hair standards of Eugen Fischer.[6]

15. *Additional.*—Occasionally it may be found necessary or advisable to use certain accessories in anthropological work on the living, such as the finger-print outfit, or the apparatus for determining blood-pressure, chest capacity, sensibility, etc.; but these are well-known medicolegal or physiological instruments which do not call for a specific description in this place.

SELECTION OF MEASUREMENTS

As already mentioned, the number of practicable measurements on the human form, both in life and on the remains, is infinite. Moreover, every one of these measurements may be of anthropological value if taken by the same method on sufficiently large numbers of individuals of various racial, environmental, social, or defective groups. But it is self-evident that for practical purposes we must make for each separate piece of investigation a careful selection of those measurements which on the one hand will fulfill the objects of our study, and which on the other hand will enable us to secure observations on the largest possible number of individuals, and not impede a prompt preparation of the data for publication.

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[1] Échelle chromatique des yeux. Instructions Anthropologiques générales, 2 ed., Paris, 1879. Consists of four series of colors, brown, green, blue and grey, with five shades to each.

[2] *Bull. Soc. d'Anthrop.,* Paris, 1892, 384–7; also, Tableau des nuances de l'iris humain, Paris, F. Durand.

[3] Twelve shades, on black strips; Queen & Co., Phila. Same firm furnishes 31 "Standard Colors for Artificial Eyes," which are slightly more useful.

[4] Obsolete.

[5] To be had through the Anthropologische Institut der Universität, Zurich. Consists of a case with aluminum plate and 16 glass eyes which protrude from eyelid-like apertures in the plate.

[6] Made by F. Rossett, Freiburg i. B. Consist of a metal case containing 30 different colored samples of artificial (cellulose) hair. Desc. by Fischer in "Die Bestimmung der menschlichen Haarfarben," *Korbl. d. d. Anthrop. Ges.,* 1907, xxxviii, 1–7.

The selection of the measurements for a particular piece of study is not as difficult as might seem, once we are well conscious of the exact aims of the study to be undertaken. If it is to be a study of the laws of growth in the child, we shall naturally devote our attention mainly to the dimensions of the body as a whole and to those of its main segments, the head, neck, trunk and limbs. We may disregard in this case the growth of the secondary parts such as the ears, nose, mouth, hands and feet, and possibly even the development of the face as a whole, which should form the subject of special studies. Should our object be racial comparison, the main attention will be centered in stature, sitting height, possibly the span, and the dimensions of the head, face, nose and perhaps also the ears. But if the object of the research is to be a comparison of two or more environmental or social groups, then it will be necessary to pay close regard, besides the measurements just mentioned, also to those of the shoulders, chest, hands, and feet, and possibly also to those of special parts of musculature. Same rules will naturally be observed in work on the skeleton.

Besides such more general studies there will be occasions for research on single parts or organs, which will call for detailed measurements of these, together with those on parts that stand in important correlation. Finally, in the study of individual variations of parts, we may practice detailed measurements which will be used on no other occasion and which it would be of no use to complicate by measurements on unrelated parts or organs.

In preparing for measuring the living, the student must consider, in addition to the interests of the work, also the sensibilities of his prospective subjects. He must particularly bear in mind that modesty, though it may differ in shade or degree, is a universal virtue which cannot be offended with impunity. Fortunately, measurements which would call for exposures likely to be resented are in general those of secondary value only. Moreover, a light garment will in no way interfere with the accuracy of measurements, as for instance those of the chest, the maximum breadth of the pelvis, etc. To demand more than an accustomed exposure would spoil the chances of success of the investigator in many a tribe of primitive people, and might even prove dangerous. Clean mind and clean work are both requisites, as well as great tonics.

Blanks.—The subject of blanks has already been covered in the main (p. 40). Anthropological literature contains many examples of proposed universal blanks, from those of Broca, Topinard, and the British Association, to those of von Luschan and the overcomplex ones of Török or Rudolf Martin. The essentials are however the same in all, and if any rule should be given the student in this connection it is to begin his independent work with these essentials, and let experience advise him as to extensions.

The general type of blanks used on the living by the author are reproduced on the next pages. Though based on long experience and seeming to him satisfactory, they are not given here to be blindly followed. He himself modifies them according to occasions. He may add, for instance, the sternal notch height, breadth of shoulders, and breadth of the pelvis; he may eliminate the span, the ear measurements and other determinations. The blanks relating to skeletal material will be dealt with later. Author's general blank for children, which on account of the diversity of ages is printed on an individual sheet, is also here shown. It is equally subject to modifications, according to circumstances. Both sets of the blanks here given will be seen to lack various measurements which have been used more or less extensively in anthropometry, such as the various subsidiary heights (to shoulder, nipples, xiphoid, umbilicus, pubis), those that apply to the various segments of the limbs, etc. The reason is that except in special studies none of these measurements is of prime importance, and in many cases either the exposures they call for or the uncertainty of their landmarks, offer serious difficulties to effective, accurate work. In case of exceptional opportunity or special interests of the observer, any of these measurements may, of course, be included in the general scheme.

LANDMARKS AND METHODS

So far as measurements on the living are concerned, it will be of advantage to speak of landmarks and methods jointly. Moreover, only those measurements will be considered in this place which are practiced in the anthropometric work of the Smithsonian Institution. Information as to others may be readily obtained from Broca,[1] Topinard,[2] Martin,[3] and the existing International Agreements.

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[1] Broca (Paul), Instructions anthropologiques générales. 12mo, 2 ed., Paris, 1879.
[2] Topinard (Paul), Éléments d'Anthropologie générale. 8°, Paris, 1885.
[3] Martin (Rudolf), Lehrbuch der Anthropologie. 8°, Jena, 1914.

ANTHROPOLOGY

————————Expedition

Tribe. Measurements: A.

No.	Name	Sex	Approx. Age	Deformation of Head	Stature	Max. Span	Excess of Span Over Height	Sitting Height	Sitting Height, per cent. of Total Height	Head: D. Ant. Post. Max.	D. Lateral Max.	Cephalic Index	Height Base of Meatus Line to Bregma	Mean Cephal. Height Index	Cephalic Module	Cephalic Module vs. Height	Face: Menton-nasion	Menton-crinion	Height of Forehead (Nasion-crinion)

B.

No.	Diam. Bizygom Max.	Facial Index	Physiognomic Index	Diam. Frontal Min.	Diam. Bigonial	Nose: Height to Nasion	Nose, Width Max.	Nasal Index	Mouth Breadth	Chest, D. Lateral	Chest, D. Ant. Post.	Chest Index	Left Hand, Length	Left Hand, Width	Hand; Index	Left Foot, Length	Left Foot, Width	Foot Index	Left Leg Circum. Max.

ANTHROPOLOGY

——————————Expedition

Tribe. Inspection: C.

No.	Skin Color	Hair				Moustache and Beard		Eyes		Forehead	Supra-orbital Ridges	Eye-slits	Malars
		Color	Character	Gray	Lost	Color	Character	Iris	Conjunctiva				

D

No.	Nasion Depression	Nose	Nasal Septum	Lips	Alveolar Pregnathism	Chin	Angle of Lower Jaw	Body and Limbs	Toes	Breasts

ANTHROPOLOGY

——————————Expedition

Tribe. Physiological: E

No.	Temperature (sub-Lingua)	Pulse	Respiration	Time of the Day	Present State of Health, etc.	Left Ear			Teeth	Hand Pressure		Weight
						Height	readth	Index		Right	Left	
						Max	*Max*					

CHILDREN.

SMITHSONIAN INSTITUTION
UNITED STATES NATIONAL MUSEUM

People..........
Tribe.......... Locality.......... Sex..........

Measurements

No.......... Age (real).......... (appar)..........
Deformation of head..........

BODY:

Stature..........
Max. finger reach..........
Height sitting..........
Height to sternal notch..........

HEAD:

Length..........
Breadth..........
Height (biaur. l.-bg.)..........

FACE:

Length to nasion..........
Length to crinion..........
Breadth, bizygom..........
Diam. front min..........
Diam. bigonial..........

Nose:

Length to nasion..........
Breadth..........

Mouth:

Breadth..........

Left Ear:

Length..........
Breadth..........

MISCELLANEOUS:

Chest:

Breadth at nipple height..........
Depth at nipple height..........

Left Hand:

Length..........
Breadth..........

Left Foot:

Length..........

Breadth..........

Left Leg:

Girth, max..........

Weight of Body..........
(With shoes and dressed, but without outer garments.)

OBSERVATIONS

Color of skin..........
Color of eyes..........
Color of hair..........
Nature of hair..........

Forehead..........
Supraorb. ridges..........
Eye-slits..........
Malars..........
Nasion depress..........
Nose..........
Nasal septum..........
Lips..........
Alveol. progn..........
Chin..........
Angle of l. jaw..........
Body and limbs..........
Toes..........
Breasts..........

PHYSIOLOGICAL:

Pulse..........
Respiration..........
Temperature..........
Time of day..........
State of health (see tongue)..........
Strength:

Pressure r. hand..........
Pressure l. hand..........

TEETH:

- 1st
  - upper
    - r.—i. 1, 2, c, pm. 1, 2
    - l.—i. 1, 2, pm. 1, 2
  - lower
    - r.—i. 1, 2, c, pm. 1, 2
    - l.—i. 1, 2, pm. 1, 2
- 2d
  - upper
    - r.—i. 1, 2, c, pm. 1, 2, m. 1, 2, 3
    - l.—i. 1, 2, c, pm. 1, 2, m. 1, 2, 3
  - lower
    - r.—i. 1, 2, c, pm. 1, 2, m. 1, 2, 3
    - l.—i. 1, 2, c, pm. 1, 2, m. 1, 2, 3

MEASUREMENTS OF THE BODY

The directions to be given will for the most part strictly follow those of the International Agreements, as far as these go; but for the benefit of the student there will be a number of explanatory changes in the wording, and also a number of additions, all of which will be plainly indicated.

Stature—The stature is to be measured on the anthropometric plane of Broca, or an equivalent strip or tape (see under Instruments), with a square. The subject stands erect, on level surface, with heels together, and with these, the buttocks and the shoulders applied to the vertical (wall, rod, tree, etc.) on which is fastened the anthropometric plane, while the head is held so that the visual as well as the biauricular axis are horizontal. The occiput will frequently touch the vertical in this position, but it is not obligatory that it should do so. The arms hang in natural position. The height of the vertex is ascertained by means of the square. Observer stands slightly to the left of the subject, manipulates the square by holding it lightly in the left hand, and reads the measurement on the right margin of the plane. The square is applied to the head horizontally twice or three times in succession, to facilitate correct reading, and with sufficient impact to feel the skull resistance. Care must be exercised not to make an error in the reading.

The method as given here differs slightly from the Geneva agreement in that it provides, through the application of the heels, buttocks, and shoulders to the vertical, of a strictly standardized posture which will also serve for other measurements. There is no appreciable difference in the measurement by the two methods if taken with sufficient care; but the modification here given assures a greater uniformity of results as well as a greater ease of procedure. It is moreover strictly speaking the method of Broca[1]; and it is the method of the Geneva International Agreement for sitting height (q. v.). It would be incongruous to take the total height in one standard position and the sitting height in another.

Should the development of the buttocks interfere, as may occasionally happen in women, the subject is not forced against the vertical, but allowed to stand slightly in front of the same.

2. *Height to the Supra-sternal Notch.*—Instruments: A level and a plumb, or the anthropometer. The level has already been described

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[1] Instructions, etc., 119. "Le *vertex* est le point culminant de la tête, lorsque le sujet debout et adossé au mur regarde droit devant lui. La hauteur du vertex n'est autre chose que la taille du sujet. On la mesure en faisant descendre la grande équerre sur sa tête."

(p. 55). In the absence of the specially made tube, use may be made of a flat piece of wood, such as the ordinary tongue depressor, which is applied edgewise into the notch. Method: Subject retains position held during measurement of stature. The level is pressed into the deepest part of the sternal notch, brought to and supported in horizontal position, the lead is dropped to the floor or ground with the string just clearing the abdomen, the cord is pinched by the thumb and forefinger nails at the lower edge of the level, the subject steps aside, and the measurement is read off against the vertical plane.

With the anthropometer the measurement is taken direct, with the instrument in front of the subject.

3. *Shoulder Height.*—This is an unsatisfactory measurement, on account of the frequency of a faulty holding of the shoulders. It should be taken on both sides, record being made either of both the measurements or of their mean. Landmarks: the upper surface of the outermost part of the acromion. Method: Similar as with measurement from sternal notch.

4. *Span.*—The horizontal distance from tip of medius to tip of medius, in maximum extension of the arms. Instruments: A vertical molding (or wall) against which to apply one of the fingers, and a broad horizontal scale on which to take the measurement (see under "Instruments"). Method: The subject whose stature and perhaps also sternal or shoulder height have just been measured, extends one of his arms horizontally until the medius is applied to the provided vertical, and raises the other arm into a similarly horizontal position. The observer applies his thumb nail to the medius of the free arm, and watching the subject, as well as the continued application of the medius of the arm first raised to the vertical, he directs him or her to expand the arms as much as possible. As the expansion takes place the thumb of the observer is pushed along the scale, until the maximum is reached. That the latter has been reached can usually be told from the attitude and expression of the subject. The arms are then dropped and the measurement indicated by the nail of the observer's thumb is read on the scale. The whole procedure is quite simple. Normality of the parts entering into the measurement is of course essential.

5. *Sitting height.*—The Geneva Agreement stipulates as follows: "*Sitting height.*—The subject sits on a horizontal and resisting seat about 30 to 40 cm. high (this height being proportionate to the stature of the subject); the knees are flexed; the dorsal aspect of the trunk is

to make contact with a vertical plane, or with the anthropometric rod at two points, viz., in the sacral region and again between the shoulder blades; the axis of vision is horizontal. The height of the vertex above the surface of the seat is to be measured."

The directions here given need no alteration. The height of the bench for American adults, whose average stature is superior to that of most other Whites, should not be lower than 45, and may conveniently be 50 cm. (see under "Instruments"). In taking the measurement special care must be taken in each case that the sacral region be well applied to the vertical. The occiput in this position generally touches the vertical plane.

MEASUREMENTS OF THE HEAD

Length.—The maximum glabello-, occipital diameter of the vault.

Instrument: The spreading compass or calipers (compas d'épaisseur, Broca or Hrdlička).

Landmarks: Anteriorly—the most prominent point of the glabella; posteriorly—the most prominent point on the occiput as shown by the maximum determinable spread of the branches of the compass (Intern. Agr.).

Method: According to older methods (see Bertillon, Martin), the end part of each branch of the instrument was held in one hand, as in measuring the face. For measurements of the head this is somewhat clumsy. A better method is to hold the compass so that its butt (or joint) rests on the hypothenar eminence of the hand, the two proximal parts of the branches reposing respectively on the ball of the medius and on the second joint of the forefinger, while the thumb holds the instrument to the hand. The observer applies the thumb and middle finger of his left hand, in contact, to just below the glabella, places the free end of the left branch of the compass on these fingers so that the point touches the glabella, and applies the left forefinger over the end. This gives a ball-and-socket arrangement which enables the measurer to hold the point of the left branch of his compass steadily over the glabella without fear of displacement. This branch of the instrument needs no further attention. The right hand is now moved partly around the proximal part of the compass, so that the two branches rest on the ball of the fourth and on the second joint of the middle finger, and are held and controlled by the ball of the thumb and the ball of the forefinger. This hold permits not only an easy handling of the instrument with perfect control, but affords also a great facility for regulating the pressure. The free end of the right branch is then applied over and somewhat to one side of the median line of the most prominent part of the occiput, and is moved up and down in saw-tooth fashion from side to side of the occiput until the maximum length is encountered. The eyes watch only the scale. The ease of manipulating the instrument when handled in this manner is very gratifying. (Fig. 11.)

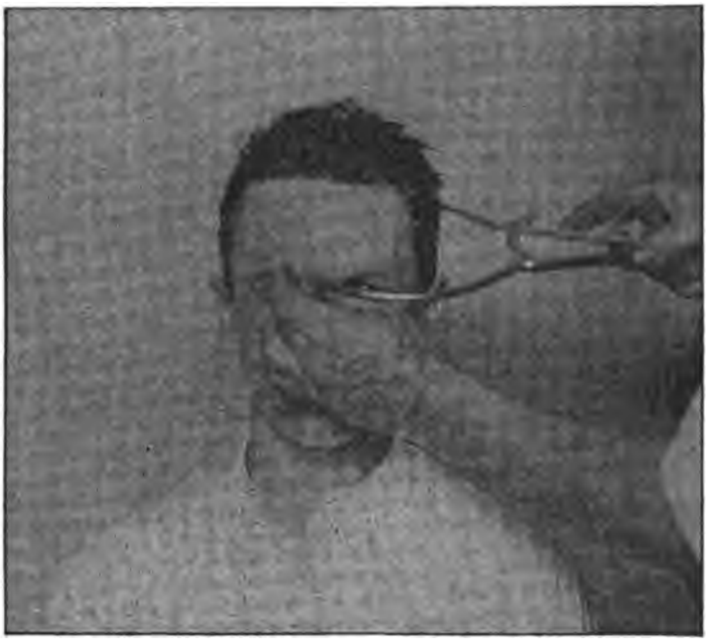

FIG. 11. Method of holding instrument in measuring the length of head.

Breadth.—The greatest transverse diameter in horizontal plane which can be found on the vault by the spreading compass (compas d'épaisseur, Broca or Hrdlička).

Landmarks: Determined solely by the maximum breadth of the skull above the supra-mastoid and zygomatic crests (Intern. Agr.).

Method: The instrument is held as in first position for measuring the length, and this position is retained. The left hand is placed lightly on the top of the head of the subject, assisting in bringing the latter into the most convenient position for taking the measurement; the instrument is applied horizontally somewhat above what appears to be the maximum breadth, and is moved in a zigzag way antero-posteriorly, descending and again ascending by zigzags, until the maximum breadth is found. The eyes watch only the scale. It is necessary to repeat the movements in an ascending and possibly once more in a descending direction, until the observer is positive that the maximum breadth has been ascertained.

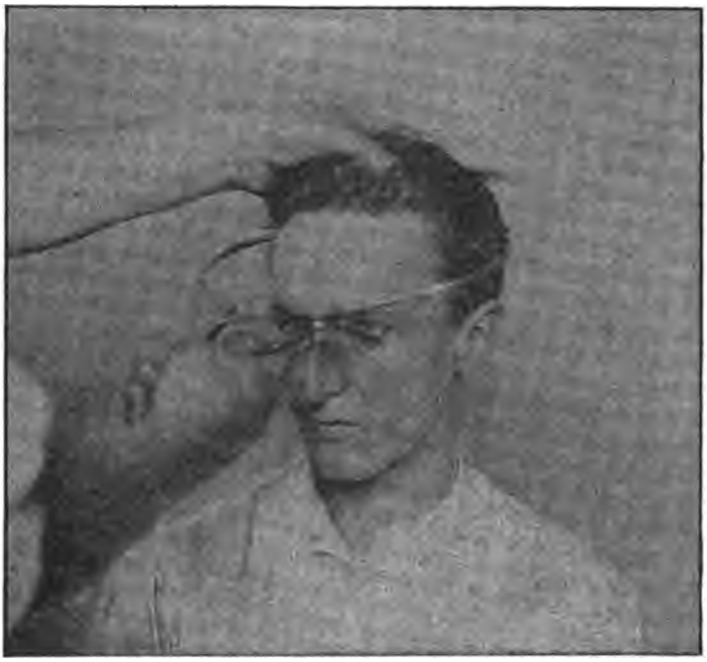

FIG. 12. Method of holding instrument in measuring the breadth of head.

Height.[1]—The height from the middle of the line connecting the floor of the auditory canals to bregma.

Instrument: The spreading compass of Hrdlička (Fig. 10).

Method: The instrument is held by the right hand just below the joint. The head of the subject being steadied by the left hand, one branch of the instrument is gently introduced into the left ear as far as the guard permits, and the same is followed with the right ear.

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[1] The Monaco Agreement stipulates that the height of the head be taken from "the superior border of the auditory opening" to the "vertex"; but no satisfactory method for taking the measurement is offered or has ever been devised. The method here described has been practiced by the author since 1898 and found effective.

The compass is then slightly raised to assure penetration as far as the guards allow, is taken hold of a short distance above the scale by the left hand, allowed to sag down by its own weight, and held in position. The ulnar side of the hand that holds the compass should for greater steadiness repose on the head of the subject behind the instrument. The scale of the compass is now brought as near as possible over the bregma, the spread of the branches of the compass is noted on the scale, the distance from bregma to lowest part of the scale is carefully ascertained by the rod of the sliding compass, and the operation is completed. All that is now necessary is to read off on a previously prepared scale the total height from the base line of the points of the compass to the lowest part of the scale of the same at the spread observed in the subject at hand, and to deduct from this the distance between the bregma and the scale. Special care must be exercised that neither of the branches (particularly that in the right ear) slip out of the meatus. (Fig. 13).

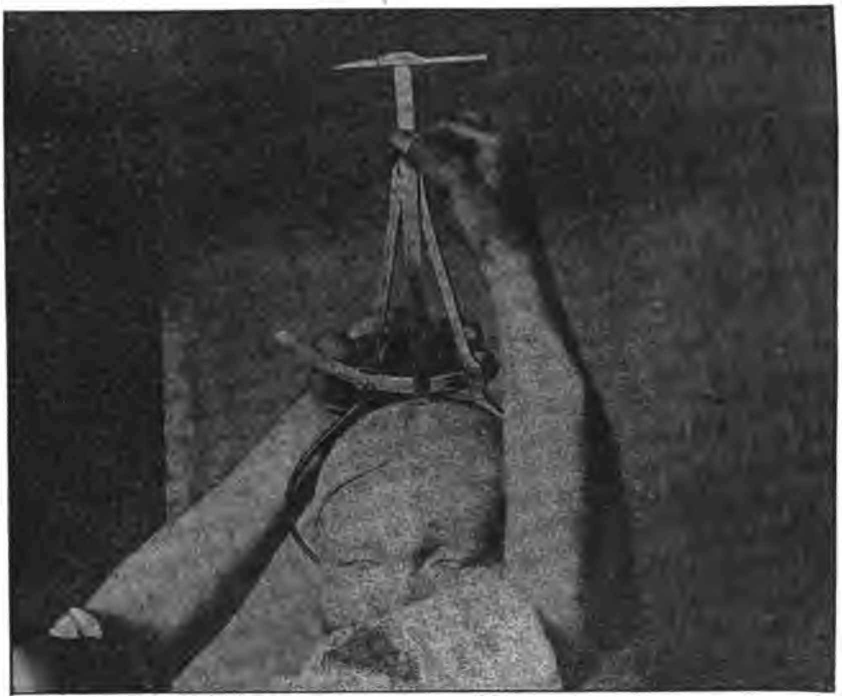

FIG. 13. Method of holding the instrument in measuring the height of the head.

This method is readily learned and causes the minimum of inconvenience to the subject (particularly if the points of the instrument are warmed in water or by the breath of the observer before introduction), and with due care it gives results which vary within less than 3 mm. The time required is scarcely more than the average time for ascertaining the head length. The external portions of the floor of the meatus, while not as perfect landmarks as could be desired, give with this method and instrument, in the author's experience, results that are more satisfactory than those obtained by any other method or instrument so far devised for taking this important measurement of the head. The preference of bregma to the vertex for the superior 'point de repère,' is in accordance with the Geneva Agreement, which stipulates two heights of the vault and both to the bregma.

MEASUREMENTS OF THE FACE.

The face in the living can hardly be considered without including the forehead, which contributes in an important way to the physiognomy. In consequence certain measurements of the "face" include the frontal part of the head up to the line of the hair.

The essential measurements on the face are its anatomic and physiognomic heights, and its greatest breadth; but generally it is also advisable to include the smallest frontal and the bigonial diameter.

Instrument: The spreading compass (Broca or Hrdlička).

Preliminaries: The location of the *nasion*, and the middle point of the hair line (*crinion*), may with advantage be marked beforehand by aniline pencil.

The *nasion* should correspond as closely as possible to the anatomical nasion, *i.e.*, the mid point of the naso-frontal suture. In a certain proportion of subjects this point may be felt by the observer's finger nail or the point of a pencil; but in the majority we must rely on knowledge of its location derived from extensive observation on skulls and dissecting room material. It is always situated above a horizontal line connecting the two inner canthi.

The *crinion* is the mid point of the hair line, where this forms a regular arc. Occasionally a more or less marked V-shape extension of the hair downward in the median line will mar this arc, in which case it will be requisite to extend the lateral parts of the arc until they connect and mark the crinion in the middle of this line. But little difficulty will be experienced in this connection.

Face Length, Anatomical.—The distance from the menton (the lowest point in the middle of the bony chin), to the nasion.

Method: Hold large spreading compass so that the points repose on the balls of the two forefingers. Ascertain with the projecting part of the left forefinger the lowest part of the chin, apply to it the point of the compass, and hold in position by the forefinger. Open the instrument sufficiently, apply little finger of the right hand to the head of the subject for support, bring the right forefinger with the end of the right branch to the forehead a short distance above the nasion, and without moving the skin up or down apply the point of the instrument carefully to the nasion, at the same time reading the scale.

Height to Crinion.—Method: Without removing the hands or instrument after the measurement to nasion has been secured, the upper branch of the compass is elevated until it touches the crinion, and the measurement is read off.

The manipulation is simple and the values of the two measurements are easily carried in mind until they can be recorded.

Face Breadth.—The maximum bizygomatic diameter.

Landmarks: The most widely separated points on the external surface of the zygomatic arches (Intern. Agr.).

Method: Hold instrument as in measuring facial heights. Bring over zygomatic arches, feel with forefingers their maximum convexity, apply points of instrument with sufficient pressure to feel resistance of the bone, and pass forward and backward in up and down zigzags, watching the scale; repeat process in opposite direction, and perhaps once more forward and backward, until the maximum breadth is ascertained.

Diameter Frontal Minimum.—The minimum frontal breadth, or the shortest horizontal diameter between the two temporal crests on the frontal bone.

Instrument: Compas d'épaisseur, Broca or Hrdlička.

Method: Hold instrument as for measuring the facial heights and breadth. Search with forefingers above the lateral angular processes of the frontal for the deepest part in the curve of each temporal line; when found slip the points of the forefingers behind the lines, apply points of compass to the same, and read measurement.

Diameter Bigonial.—Instrument: Compas d'épaisseur, Broca or Hrdlička.

Landmarks: The gonions or points of the angles of the lower jaw. The separation of the angles is measured by applying the compass to the most prominent points on their external surface.

Method: Hold instrument in same way as for the other facial measurements; ascertain most prominent points of angles with tips of forefingers, slip these a little behind, apply points of compass to the points just ascertained and read off the measurement.

Height of Forehead.—The height of the forehead is the difference between the menton-nasion and the menton-crinion diameters.

MEASUREMENTS OF THE NOSE, MOUTH, AND EARS

Nose: Length.—The length (or "height") of the nose from the nasal septum where this joins the upper lip, to the nasion (Intern. Agr.).

Instrument: The sliding compass.

Method: Apply left hand over the head of the subject in such a way that the thumb is a short distance above the nasion. Place the fixed branch of the compass against the thumb, and with this bring gently to touch the nasion. Push movable branch of compass to point where the line of the septum joins the skin descending from the nose to the upper lip, remove instrument and read measurement.

In cases where no point of demarkation between the upper lip and nasal septum exists it will be necessary to press slightly on the lower branch of the instrument in the line of the septum, until the requisite point is reached. The student bears in mind that his object is to ascertain the correct length of the nose alone.

Breadth.—The maximum normal external breadth of the nasal alæ, determined without the exertion of any pressure.

Instrument: The sliding compass.

Method: Hold instrument in right hand, with thumb on the sliding branch and points upward. Place dorsal parts of the third and fourth fingers of the left hand on the subject's chin, with the forefinger free; apply distal branch of compass to your forefinger, and with this acting as a support bring to the most prominent part of the right nostril; push sliding branch gently to most prominent part of left nostril, turn instrument slightly forward and backward to ascertain that both branches are touching and not compressing the skin, remove and read measurement.

Remarks.—The position of the left hand of the observer in connection with both measurements on the nose is of considerable importance and assistance, assuring a safe, quick and accurate measurement, and giving the subject a sense of confidence. In measuring the breadth of the nose, care must be taken that the nostrils of the subject are not dilated; a more or less unconscious dilatation will take place in some subjects when the measurement is to be taken.

Mouth.—Breadth: The distance between the angles of the mouth at points where the mucous membrane joins the skin, with mouth naturally closed, without tension.

Instrument: Sliding compass.

Method: Apply forefinger of left hand to the chin and the medius below the chin. Place fixed branch of instrument on forefinger, apply to right corner of the mouth, bring point of sliding branch to left corner (without exactly touching either), remove instrument and read measurement.

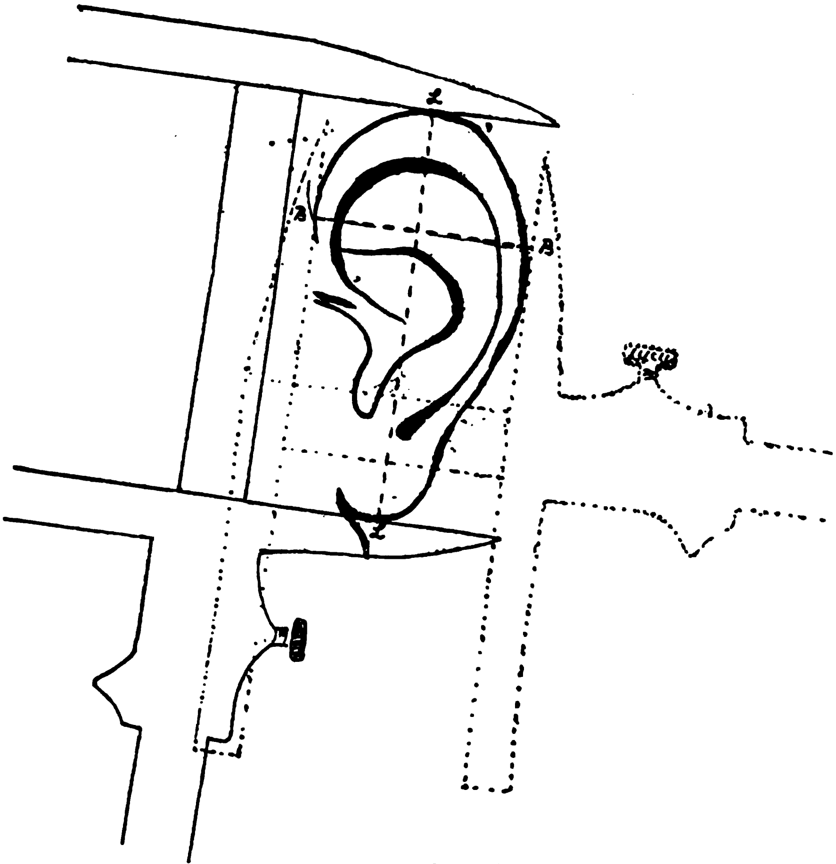

FIG. 14. Length and breadth of ear.

Left Ear.—The left ear for a right handed observer is much easier to be measured and should therefore be the ear measured on all occasions. The two measurements to be taken are the greatest length, and the greatest breadth at right angles to the length. Both are taken with the sliding compass (Fig. 14).

Length Maximum.—Landmarks: Superiorly the highest point on the border of the helix; inferiorly the lowest point on the lobule. The rod of the compass should be held parallel to the long axis of the ear; use no pressure (Intern. Agr.).

Method: Place third, fourth and fifth fingers of left hand above the ear, apply fixed branch of compass to ball of the medius, bring it gently with this to the uppermost part of the ear, push sliding branch to lowermost point of lobule, holding instrument parallel to the long axis of the ear, and read measurement.

Breadth.—Distance between two lines parallel to the long axis of the ear, one of these lines being tangent to the anterior, the other to the posterior border of the helix (Intern. Agr.).

Method: Place three fingers of left hand above the ear as for preceding measurement. Apply fixed branch to ball of the free thumb, and with this bring to the anterior limit of the cartilage of the helix, which can be done most readily by applying a little pressure on the point of your instrument so that this sinks in front of the helix. Hold the fixed branch parallel to the long axis of the ear, bring sliding branch to the outermost part of the ear, and read measurement.

MEASUREMENTS OF THE TRUNK AND LIMBS

Breadth of Shoulders.—The most satisfactory breadth is that between the great tuberosities of the humeri, which are easily ascertained in all subjects.

Instrument: Large sliding compass (Topinard, Martin, or Hrdlička).

Method: Apply branches of compass to points indicated with sufficient pressure to feel the unyielding resistance of the bone, and read measurement. The arms in natural pendent position.

Diameters of the Chest.—The most satisfactory level for measuring the diameters of the chest is that at the height of the nipples in men, and at the corresponding height of the upper border of the fourth chondrosternal articulation in women. The developmental and racial variations at this point appear to be better marked than they are in any other part of the thorax.

Instrument: The large sliding compass (Topinard, or Hrdlička).

Method: Transverse diameter: Subject stands in natural, easy, erect position. The forearms are flexed at about right angles, and the arms are lifted forward and upward to about 30 degrees from the body. They are directed to be held limp without any tension, and the examiner satisfies himself that there is no tension by lightly taking hold of the forearms and moving the arms slightly up and down. The object of the position is on one hand to relax all the thoracic muscles, and on the other to permit the application of the instrument. The same position in every respect is preserved for the antero-posterior diameter.

The large compass is now applied to the chest in such a way that its rod lies directly over the nipples (or corresponding line in women), the fixed branch is pressed against the thorax until it meets with the resistance of the ribs, and the movable branch is applied repeatedly to the opposite side of the thorax, with equal pressure, during inspiration and expiration, until the medium between the two can be arrived at. It is the medium which is recorded. The instrument is held so that its plane is at right angles to the vertical plane or axis of the thorax.

The *antero-posterior diameter* is taken so that the fixed branch of the compass is applied to the nipple line, the rod of the instrument to the ribs on the left side, and the movable branch to the posterior part of the thorax, the instrument being held again at right angles to the vertical axis of the chest. Here also we take repeated measurements until the medium between normal inspiration and expiration is ascertained, and this is recorded.

Measurements of the Limbs.—It is advisable to measure the left hand, left foot, and left leg, partly because of greater convenience, partly because in a large majority of persons the left limbs are less affected by work, and possibly also, at least in the case of the hand, by injuries.

Left Hand. Length.—The International Agreements have nothing on the measurements of the hand or foot; but measurements of both are indicated in Topinard's Eléménts etc., 1134–35, as well as in Martin. Those practiced by the author may be defined as follows:

The length of the hand in the living extends from the middle of the line connecting the proximal limits of the thenar and hypothenar eminences, to the end of the medius, with the hand in full extension.

Instrument: Sliding compass.

Method: Take a sheet of blotting paper, apply to points just given (which if indistinct can easily be ascertained by flexing the hand upon the forearm), mark mid-point with aniline pencil, and secure measurement with hand in full extension.

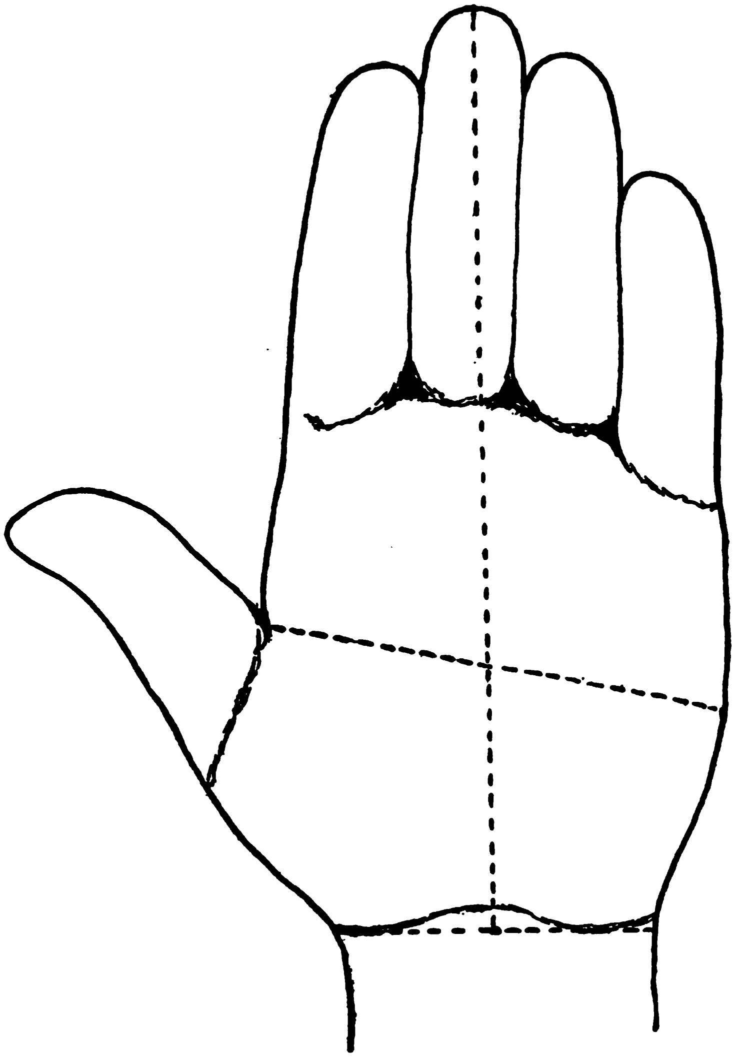

Fig. 15. Length and breadth of hand.

The easiest way to take the measurement is by placing observer's left hand under that of the subject with thumb close to the point from which the measurement is to be taken; applying the fixed branch of the compass to the observer's thumb and with this to the marked point at the wrist; seeing to it that the hand is fully extended, and bringing movable branch into light contact with the point of the medius. The rod of the compass is held parallel to the wrist-point—medius line.

Breadth.—The most expressive breadth of the hand is that across the palm, at nearly right angles to the length.

Instrument: The sliding compass.

Method: With hand in full extension, apply fixed branch of compass to the angle formed by the thumb and the radial side of the palm, and if necessary compress skin lightly until the point on which the instrument rests is in straight line with the radial surface of the forefinger and palm. The rod of the compass lies applied across the palm, and the moving branch is brought to a point on the ulnar side of the palm midway between the basal (metacarpo-phalangeal) groove of the little finger and the line limiting the hypothenar eminence.

The most satisfactory way of taking this measurement is for the observer to place his left hand under that of the subject so that the tip of his medius is just below the junction of the thumb and palm, and his thumb is on the palm itself. The point of the movable branch of the compass is now applied to the ball of the observer's medius, is brought with this to the required position in the palm-thumb angle of the subject's hand, and the fixed branch is brought slowly to the requisite point of the ulnar side of the palm. This latter point may be marked beforehand, but its location can be easily estimated. The breadth thus obtained is nearer the maximum, more logical, and easier to take, than would be that at strictly right angles to the length and is much more characteristic than the breadth across the metacarpo-phalangeal articulations (Fig. 15).

Left Foot. Length.—Length maximum, parallel with the long axis of the foot.

Instrument: The large sliding compass.

Method: The easiest way to secure this measurement accurately is to direct the subject to place his left foot upon the bench (usually that which has been used for determining the height sitting), without pressure, putting all his weight on the right limb. The large sliding compass is then applied so that its rod lies parallel with the long axis of the foot, its fixed branch touches the heel, and its movable branch is brought lightly to the most distal part of the longest toe.

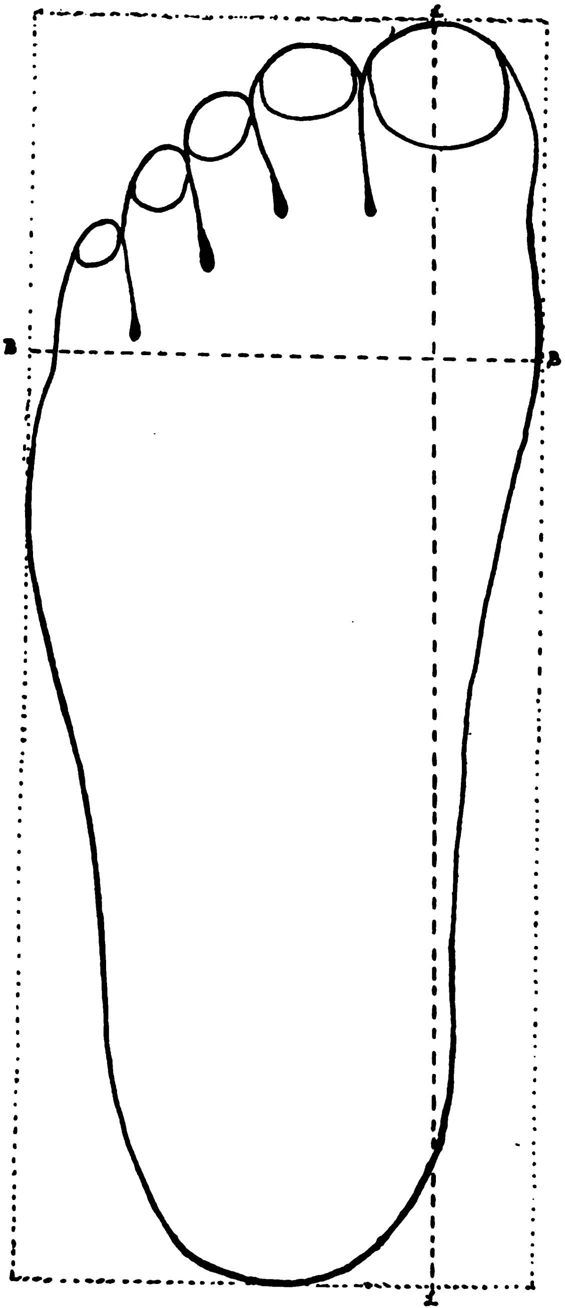

FIG. 16. Length and breadth of foot.

Breadth: The maximum breadth of the foot, at right angles to the length.

Instrument: The large sliding compass.

Method: Apply fixed branch of instrument to inner side of foot parallel with its long axis, and bring movable branch lightly against most prominent part on the outer side of the foot (Fig. 16).

Girth of Calf.—Maximum circumference of calf. Measurement useful racially, and also in general for comparison of musculature.

Instrument: Anthropometric tape.

Method: The left foot is placed on a bench, as for measurements of the foot itself, and it is brought forward so that the leg forms a little larger than a right angle with the thigh, to insure relaxation of all muscles. The tape, held between the thumb and fore-finger of each hand, is then applied somewhat above what appears to be the maximum bulge of the leg, and is brought snugly around the leg but not tightly enough to cause an impression, and a mental note is made of the measurement. The tape is then moved, with a side to side motion, slightly lower and the measurement is observed again; and the process is repeated until the maximum girth has been determined.

OBSERVATIONS ON THE LIVING

As in the case of measurements so in that of visual observations there is possible a great range of detail, which on special occasions and in studies of single organs may be fully justifiable and even necessary, but which has no place in work of more general, routine nature. Thus in the case of the nose there is a possibility of making interesting detailed notes on the height and nature of the septum, on the characters of the point, on the shape of the nostrils, on the stoutness and other characteristics of the root; in the case of the eyes, on the detailed characteristics of each lid and canthus, with almost endless details on the coloration. All this, however, is impossible under the usual stress of work both in field and in the laboratory. Here again, as in the case of the measurements, we must subordinate whatever is not essential to the number of subjects, and the possibility of prompt elaboration of data. But there are certain minima which the observer ought not to pass if his work is to be fairly rounded out, and it is on these that attention will here be concentrated.[1]

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[1] For greater minutiæ the student may be referred especially to the outlines of the anthropometric work on Austria's prisoners carried on during the war by Rudolf Pöch, published in 1915–17 in the *Mitt. Anthrop. Ges.*, Wien.

Important features in this connection are the order of procedure, and especially the mode of recording. The procedure should be as far as possible logical, the eye passing from organ to organ in the most natural order; and the recording is best done in definite, steadily adhered to abbreviations, which are recorded like measurements in columns and can eventually be summed up and analyzed in much the same manner.

Another important subject is the characterizing of certain observations, such as for instance the thickness of the lips, size of the eye aperture, quantity of beard, etc. To properly describe such variations we are in absolute need of definite, well-known standards or media, and the most available and intelligible standards to us of the white race are those of our own, the white people. To become properly acquainted with these "means" must therefore self-evidently be one of the main aims of the worker in physical anthropology.

All observations should be made in good and as far as possible even (northern) light, never in dusk or in direct sunlight; and at the most effective visual distances for the student. And of course, where possible, the observer will use well-known artificial standards.

The following classification of characteristics agrees in essentials with that of anthropologists in general, differing only in a few details, as indicated by prolonged experience on varied races. For the sake of brevity it is given in a somewhat schematic form, which will need but little explanation.

As to abbreviations, the student is free to adopt such as will best suit him. The author has thus always used the easily made and read sign of + for "medium," "average," "normal," for which we have no other symbol. Terms often called for, such as "slight" (sl.), or "slightly" (sl.), "some" (sm.) or "somewhat" (sm.), "moderate" (mod.) or "submedium" (subm.), "considerable" (cons.), "marked" (mk.), or "pronounced" (pron.), and "excessive" (exc.), are easily understood by all and easy to record.

COLOR OF SKIN

Remarks: Observations best taken on chest, back, or upper portion of arms. Color standards useful on dark races, but of very limited utility with whites. Student should bear in mind that pathological conditions, particularly those which affect the blood, may alter for the time being the color of the skin, even in very dark individuals; and also that even dark skins may be perceptibly changed by sunburn or long exposure to the sun.

DESCRIPTIVE TERMS

Class of Color. *Shades.*

White—florid—light—medium—brunet—dusky—light brown.
Yellow—pale yellowish or sallow—tawny (brownish yellow)—dusky yellow.
Brown—light—medium—dark—chocolate (solid).
Black—brown black—bluish black—greyish black—ebony black.

EYES

What is generally observed about the eyes is the direction of the palpebral fissure or eye-slit, a presence of epicanthus, and the color of the iris. Any other feature found to characterize an anthropological group should of course be noted. The color of the conjunctiva is more of age than racial significance.

COLOR OF EYES

Remarks: Good soft light and close attention are necessary. In Whites, and particularly Americans, a large majority of eyes are mixtures, or blends, of the blues and browns, and both parental colors may be represented, the brown aggregated about the pupil, in lake or spots, the mostly more or less modified blue outside. In rare cases the brown may be present in the form of a wedge-shaped segment; and the two eyes may be of a different shade. Eyes change in color from infancy to childhood and again during senility; and in mixed populations the change may even be from brownish to grey or bluish or *vice versa.* Mixed shades may also change perceptibly with physical condition and mental state of subject. In recording, the student may either restrict himself to noting the prevailing color (*i.e.*, that of the more distal zones of the iris), or record both this as well as the presence of the brown color or spots about the pupil.

EYESLITS

Direction: horizontal;
oblique { ext. canthi higher / ext. canthi lower } { slightly; moderately; markedly.
"mongolic" fold (epicanthus).

EYE COLORS

Classes:

Blue—light ("forget-me-nots"), medium, rich blue, slate blue.

Subclasses

Green—often merely "greenish"; commonly associated with some brown; frequent in United States.

Gray—common among northern Slavs.

Brown—light, medium, dark, very dark.

Black—really extreme of brown, appearing black, in Negroes.

Conjunctiva — bluish, pearly white, yellowish, dirty or reddish yellow.

HAIR

In quantity, the hair may be "normal" or "medium," "thick" (term in vogue among men) or "rich" (term in vogue among women and applying to length as well as profusion).

In character, it may be naturally "straight," "wavy" (slightly or markedly), "curly" (slightly, markedly), "frizzly," "wooly," or "peppercorn" (en rouleux).

HAIR-COLOR

Remarks: Among lighter Whites hair color, like eye color, changes with growth, as a rule darkening from infancy onward; it also varies perceptibly according to the state of blood and in certain pronounced mental conditions of the subject, and may present parts (particularly postero-inferiorly), strands, or tufts of more or less different shade. The color recorded is the prevailing one, with special note, if advisable, on variations. In gray-haired subjects record original color, as far as ascertainable, as well as degree of greyness ("few gray hairs," "some," "abt. 1/8, 1/3, 1/2, most, nearly all, all gray"). In dark races grayness rarely reaches pure whiteness and the hair will be yellowish. A special shade that may be difficult to classify should be described in observer's own words. Hair color may also be affected by exposure to sun, washing with alkalies, or by staining; what will be recorded will, of course, be the natural color.

HAIR-COLORS

Classes:

Blonds—Pigmentless, flaxen, straw, dull yellow, golden yellow; specials.

Intermediaries—Light brown, ashy, medium brown, medium reddish-brown.

Brunets—Dark brown, near black.

Blacks—Rusty-black, bluish-black, coke-black, black.

Reds—Light brownish-red (sandy red), medium brownish-red, brick-red, saffron red, chestnut red (or auburn); specials.

MUSTACHE AND BEARD

Remarks: The mustache (in particular) and also the beard, frequently differ in density, color, and waviness, from the hair of the head. (The pubic hair also frequently differs, but with that the observer in general is not concerned.) The mustache is often more scanty, or coarser, and in non-brunet Whites is commonly of a more reddish color than the hair on the scalp, while the beard is often more wavy. Both mustache and beard offer some interesting differences from the hair of the scalp in greying. Observations on mustache and beard among many peoples are regrettably made difficult by the practices of depilation or shaving, while those on hair are occasionally made difficult among Whites by extensive calvitia and by various artifices.

DESCRIPTIVE NOTES, MUSTACHE AND BEARD

Quantity: scarce—medium—thick.
short—medium—long.
Color: Character:

EYEBROWS

Color: Quantity: scanty—medium—bushy—connected.

FOREHEAD

Height: low—medium—high.
Breadth: narrow—medium—broad.
Slope backward: none—slight—moderate—pronounced.

SUPRAORBITAL RIDGES

Development: Imperceptible—traces—slight—moderate—medium—pronounced—excessive—supraorbital arch.

NASION DEPRESSION

Character: shallow—medium—deep; narrow and impressed; wide; combinations.

NASAL BRIDGE

Character: Straight
- Concave
  - slightly
  - moderately
  - markedly
- Convex
  - slightly
  - moderately
  - markedly
- Concavo-convex (wavy).

NASAL SEPTUM

Inclination: Horizontal
- Directed upward
  - slightly
  - moderately
  - markedly
- Directed downward
  - slightly
  - moderately
  - markedly

MALARS

Prominence: none—slight—medium—above medium—pronounced.
Size: small—submedium—medium—large.

ALVEOLAR PROGNATHISM

Grade: none—small—medium—above medium—pronounced.

LIPS

Thickness: thin—medium—above medium—thick.

CHIN

Prominence: submedium—medium—pronounced.
Form: ordinary—square—pointed.

Note: What is commonly called receding chin is generally so only in appearance.

ANGLES OF LOWER JAW

Prominence: submedium—medium—prominent.

NECK

Size: thin—medium—thick.
Length: short—medium—long.

BODY AND LIMBS

General state: thin—lank—medium—very muscular—plump—obese.
Asymmetries:

EARS

Marked peculiarities:

FINGERS AND TOES

Length: short—medium—long.
Position: normal—standing apart—crowding.
Peculiarities and Anomalies:

BREASTS

(in women who have had no children)

Shape: conical—intermediate—hemispherical.
Size: small—medium—large.
Anomalies:

PHYSIOLOGICAL OBSERVATIONS

Pulse: Subject sitting, at rest, and not soon after a meal or during fasting, after a long walk or other strenuous exercise, after or under excitement. A good method is for the observer to count by quarters of a minute, repeating until right count is ascertained.

Respiration: Same general rules as for pulse. Count immediately after taking pulse and without attracting subject's attention (important). Count by minutes.

Temperature: Same general rules as for pulse. Taken invariably under the tongue, the thermometer being introduced before we begin to take our visual observations and count the pulse; these give plenty of time for a correct record with even a slow thermometer.

Remarks: In connection with pulse, respiration and temperature, record time of day, and also invariably the condition of the tongue. A coated tongue often tells of temporary or chronic derangement which modifies the temperature, pulse, and perhaps even respiration. No records of subjects with coated tongue should be included in the eventual analysis into the "normal" series.

HAND PRESSURE

Dynamometric observations may well be restricted to pressure with each hand, leaving out traction, lifting strength, etc. The object of the observer is to secure the maximum effort in each hand and he must stimulate the subject to a maximum exertion. As a rule at least two tests are to be made with each hand, after which fatigue ensues.

Combined with these tests may be made an inquiry into right- and left-handedness, but this is not as simple as may be thought at first and will require some special preparation.[1]

MISCELLANEOUS

Other physiological observations, such as those on blood-pressure, lung capacity, acuity of perception and response, etc., may be added to the above, but are scarcely fit for a general routine examination.

TEETH

The examination as to the condition of the teeth fits best perhaps at this place. We examine for state of eruption; for abnormalities (crowding, impaction, etc.), and anomalies (persistent teeth of first dentition, congenital absence, supernumeraries, etc.); also for decay. Morphological observations are best made the subject of special study.

Combined with examination of the teeth may be that of the palate, but it is preferable to make a special study also of that structure.

WEIGHT

Except in recruiting and army camps, we are obliged, or find it advisable, to weigh our subjects with a certain amount of clothing, the weight of which may readily be approximated and eventually subtracted. The author finds it most convenient to weigh his subjects in their ordinary clothing and shoes, but without coats, wraps or hat.

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[1] See Beeley (A).—Left-handedness: *Am. J. Phys. Anthrop.*, 1919, II, No. 4, 389–400.

SKELETAL PARTS: THE SKULL

The art of measuring the skeletal parts differs in many respects from that of measuring the living and is, in fact, to a degree a field of its own. It is, moreover, a particularly attractive field, for we deal here with specimens that are not masked by other tissues, that can be handled cleanly and easily, and that are mostly completely at our disposal for reference or additional observation.

The most interesting and important part of the skeleton is naturally the cranium, and this has received from the beginnings of anthropology the most assiduous attention. The preoccupation of anthropologists with the skull,[1] particularly since the repeated discoveries of the remains of early man, has in fact been such as to overshadow the study of the rest of the skeleton, with the result that methods relating to research on the long and other bones are with some exceptions less developed and standardized than those on the skull. Yet these secondary skeletal parts are a mine of information of anthropological interest, and as time goes on they cannot but receive more and more attention. The time for a selection of the best methods of measuring as well as observation on the more important of these parts is at hand, and in the final section of this series an attempt will be made in this direction. The present section is devoted mainly to the cranium.

CRANIOMETRY

Efforts at a development of a scientific system of cranial measurements and observations date from well before the beginning of the nineteenth century. The most serious and at the same time successful steps in this direction were, however, those of Samuel G. Morton in Philadelphia in the late thirties of that century, of Anders Retzius in Sweden (1842–1860), and especially those of Paul Broca in France, from the early sixties onward. Broca's system, which was eventually comprised in the "Instructions craniologiques et craniométriques"

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[1] See bibliographies in "International Catalogue of Scientific literature," in Martin's "Lehrbuch d. Anthropologie," in author's "Physical Anthropology in the United States" 8°, Philadelphia, 1919), and in the Catalogue of the Library of the Surgeon General, U. S. A.

(8°, Paris, 1875), is, with some modifications and additions, in use to this day.

The most noteworthy contributions to the subjects of craniometry and craniology since Broca are those of Topinard,[1] Turner,[2] Schmidt,[3] Török[4], Welcker,[5] and finally, Martin[6]; but due credit belongs to many earlier as well as later well known workers, such as Blumenbach, de Baer, Lucae, Meigs, Soemmering, Wentzel Gruber, Quatrefages, Hamy, Geoffroy St. Hilaire, Flower, Davis, Thurman, Hovelacque, Virchow, and others, not to mention the most recent or still living, such as Hervé, Ranke, Schwalbe, Gustaf Retzius, Sergi, Manouvrier, Matiegka, Le Double, Boule, Giuffrida-Ruggeri, etc.

The total results of all this work on the skull are not only a great mass of data from all parts of the world, but also an elaborate and profuse technique of measurements. Many of these measurements are now, however, of little more than historical value, having been replaced by others or abandoned. Of what remains, the main part has been standardized by the International Anthropometric Convention of Monaco.

The cranial measurements that will be dealt with here are essentially those of the Monaco Agreement; but some of those included in the Agreement have since become quite obsolete, while in a few instances it is now possible to make useful additions, so that a simple reference to the Agreement would not be sufficient. The blanks to be given resemble in essentials those employed on the living (pp. 63–5). For brevity, repetition of definitions, etc., will be avoided, author's notes being restricted to such explanations as will assist the student. A number of measurements included call for special instruments which will be described in that connection. No agreement has yet been attempted as to the relative importance and definition of descriptive characters, and what will here be given in that line is of a more or less tentative nature.

Before beginning with either measurements or descriptive terms, however, it will be necessary to give due consideration to several preliminary procedures, some of which are of considerable importance.

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[1] "Élements d'Anthropologie générale," 8°, Paris, 1885.

[2] Challenger Reports, Part 29, London, 1884.

[3] "Anthropologische Methoden," 12°, Leipzig, 1888.

[4] "Grundzüge einer systematischen Kraniometrie," 8°, Stuttgart, 1890.

[5] Valuable contributions in anthropological periodicals, particularly the Archiv für Anthropologie.

[6] "Lehrbuch der Anthropologie," 8°, Jena, 1914.

Preparation of Specimens.—Before a series of crania (or bones) can be submitted to measurement or examination, the specimens must be not only well *cleaned*, but also carefully *repaired*, which is interesting work and at times calling for not a little ingenuity. For repair, about the most suitable cement is a thick paste made from fish glue, or from Page's liquid glue, with plaster-of-paris and pigment. A box of dry sand in which to place the skulls or bones while the cement is setting will also be required.

The specimens, furthermore, must be numbered and catalogued, otherwise there would inevitably be confusion. The method of numbering is immaterial, so long as the numbers do not duplicate others in the collection. The number, tribe, locality, and sex are marked with indelible ink in the most convenient location, which in the skull is perhaps the antero-inferior angle of the left parietal; and all specimens of one kind in the collection are marked in the same place. If the bone is scaly or too rough, a small parallelogram is covered neatly with oil paint and the mark made on this.

Sexing.[1]—In adults, the determination of sex, from the skull alone, while generally offering few difficulties to the well-trained observer, is not equally easy in all races, or in all individuals.

A typical masculine skull differs in practically every feature from the typical feminine one. It is larger on the whole and in all its components, it is heavier, and all its muscular insertions as well as other features are more strongly marked or developed. But in no human group is there any regular, precise line of demarcation between the male and female characteristics, taken individually or even collectively. In every lot we find male skulls which in some or all of their features are less masculine than the average, and similarly there will be female skulls that in some or all of their parts approach the masculine. Instead of a sharp dividing line we have interdigitation and continuity, as a result of which in certain cases the sexual identification of a specimen with all our efforts remains uncertain. In rare cases, even, a female skull may show more pronounced masculine characteristics than some of the less well developed male crania, and vice versa, which may lead to errors in classification.

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[1] The most important contributions to this subject (outside of the various text-books on Anatomy and Anthropology) are:

Bartels (P.), "Ueber Geschlechtsunterschiede am Schädel," Thes., Berlin, 1897.

Dureau (A.), "Des caractères sexuels du crâne humain," *Rev. d'Anthrop.*, 1873, II, 475.

Ecker (A.), "Ueber eine charakteristische Eigentümlichkeit in der Form des weiblichen Schädels und deren Bedeutung für die vergleichende Anthropologie," *Arch f. Anthrop.*, 1866, I, 81.

Manouvrier (L.), "Sur la grandeur du front et des principales régions du crâne chez l'homme et chez la femme," *C. R. Assoc. Franc.* p. *l'Avanc. d. Sc.*, 1882.

Mantegazza (P.), "Dei caratteri sessuale del cranio umano," *Arch. p. Antrop.*, 1872, II, 11.—"Studii di craniologia sessuale," *Arch. p. Antrop.*, 1875, V, 200.

Möbius (P. J.), "Ueber die Verschiedenheit männlicher und weiblicher Schädel," *Arch. f. Anthrop.*, 1907, N. F. VI, 1.

Panichi (R.), "Ricerche di craniologia sessuale," *Arch. p. Antrop.*, 1892, XX, 49.

Pittard (E.), Les segments crâniens chez l'homme et chez la femme." *Arch. d. Sc. Phys.* & Nat., 1899, 1900.—"Quelques comparaisons sexuelles de crânes anciens de la vallée du Rhône (Valais)," *L'Anthrop.*, 1900, XI, 179.—"Comparaisons sexuelles dans une série de 795 crânes de brachycéphales alpins," *Bull. Soc. d'Anthrop.*, Lyon, 1910, XXVIII, 119.—"Analyse et comparaisons sexuelles de quelques grandeurs du crâne et de la face chez les Tsiganes," *C. R. Acad. Sc. Paris*, 1911, T. 152, 208.

Welcker (H.), "Geschlechtseigentümlichkeiten des Schädels," *Arch. f. Anthrop.*, 1866, I, 120 *et seq.*

On the whole it may be said that an experienced and careful observer will have little if any difficulty in correctly identifying over 80 per cent of the crania, with which there is neither the lower jaw nor any other part of the skeleton to assist him; that this proportion will approximate 90 per cent where a well-preserved lower jaw is present; and that it will reach over 96 per cent where we have the whole skeleton. But out of each hundred there will still remain one or two skeletons which, even though complete, show such indefinite sexual characteristics that it will be impossible to identify them as either male or female with certainty.

Given a skull for sexual identification, the observer notes first the size of the vault as well as that of the face; a large size speaks normally for a male and a small size for a female. The features observed next, and in the order named, are the supraorbital ridges, the mastoids, the zygomæ, the occipital crests, the lower jaw, the palate and the teeth, the facial "physiognomy," and the base of the skull.

The *supraorbital ridges* are on the average decidedly more developed in the males than in the females. If we should characterize them as we do in practice by the terms "traces," "slight," "moderate," "medium," "pronounced," and "excessive," the male skulls will show ridges from moderate to excessive, while the female skulls will be restricted to those of from traces to moderate. Pronounced or excessive ridges do not occur in females, nor are ridges that could be characterized as only "traces" to be found in adult males. But we may have "slight" ridges in a male subadult or even adult.

The *mastoids* may be "small," "moderate," "medium," "large," or "excessive." Male mastoids generally range from medium to large, female mastoids from small to medium. Small mastoids do not occur in males nor do large or excessive mastoids occur in females.

The *zygomæ* may be "slender," "moderate," "medium," "strong," or "massive." They range in males from medium to massive, in females from slender to medium.

The *occipital crests* when well or markedly developed as a rule indicate a male. In females they range from "submedium" to "absent."

The *lower jaw* in the male shows on the average greater size, thickness, and weight as a whole, a higher body throughout, a higher symphysis especially, a broader ascending branch, an angle less obtuse than in the female, and strong condyles. A lower jaw of moderate size and strength, with a low symphysis, a rounded chin (a square chin points to male sex), a relatively low body, only moderately broad ascending ramus, delicate or but moderately strong condyles, and an angle of more than 125°, may safely be diagnosed as feminine.

The *palate* in the male skull is usually larger and appreciably broader, and the *teeth* in the male are on the average perceptibly larger than those in the female.

The *"physiognomy"* of the face, or the impression that the face with the lower jaw in position makes upon the experienced observer, is a characteristic of considerable importance in sex determination. The average male skull presents a decidedly more masculine physiognomy than does the average female cranium. This is due to a combination of factors which should be briefly enumerated. The forehead in the female skull is usually more vertical than in the male, and smoother; the borders of the orbits in the average male skull are dull, in the average female sharp; the nasal process of the frontal, the nasal bones, the malars, and the upper maxillae as a whole, are larger and stouter in the male than in the female; and the height of the upper alveolar process, between the nasal aperture and the front teeth, is greater in the male. The nasal aperture, moreover, is less high, often relatively somewhat broader, and more delicately moulded in the female. All this, together with the sexual characteristics of the lower jaw, when present, gives the face a certain expression which is of great help in identifying the sex of the skull. Unfortunately the lower jaw is often missing, and the upper face damaged or affected by senile changes, all of which diminishes or disturbs the sexual expression.

Thickness of the vault, alone, is of no decisive value in sexual identification, for while the bones of the male are on the average slightly thicker, individual thick and massive vaults are encountered in both sexes, especially among primitive peoples.

The *base of the skull* presents a complex of structures which as a whole show stronger development and larger dimensions in the male than in the female. The foramina, too, are in general larger in the male.

Sexual Characteristics of Other Skeletal Parts.—As in the sexual identification of the skull we are often obliged to consult the rest of the skeleton, if at hand, the principal sex determining characteristics of the latter may well be dealt with in this connection.

In detailed examinations we find that every bone in the body offers certain sexual differences. The most important skeletal parts for sexual identification aside from the skull are, however, the pelvis, the long bones, and the larger of the remaining parts.

As to the pelvis,[1] the important sexual characteristics which it presents may conveniently be shown as follows:

	Male	Female
Subpubic arch	V-shaped	Broader (approaching U-shaped) with diverging branches
Ischio-pubic rami	But slightly everted	Markedly and characteristically everted
Symphysis	High	Lower
Obturator foramina	Large	Smaller, more triangular
Acetabula	Large	Smaller
Greater sciatic notch	Rather close and deep	Wide and shallow
Ilia	High, more upright	Lower, more flaring in upper portion
Sacro-iliac articulations	Large	Smaller, more oblique

[1] See (besides the modern textbooks on Anatomy, and Obstetrics):

Emmons (A. B.), "A study of the variations in the female pelvis," etc. *Biometrica*, 1912, IX, 33–57.

Hennig (C.), "Das Rassenbecken," *Arch. f. Anthrop.*, 1885, XVI, 161–228 (Bibl.).

Runge (G.), "Shape of female pelvis in different races," 8°, St. Petersburg, 1888; 80 pp.

Sergi (G.), "L'indice ilio-pelvico o indice sessuale nel bacino delle raze umane," *La Clin. Ost.*, 1899, I; 7pp.

Thompson (A.), "The sexual differences of the fœtal pelvis," *J. Anat. and Physiol.*, Lond., 1899, XXXIII, 359–380.

Verneau (R.), "Le bassin dans les sexes et dans les races," 8°, Paris, 1875, 156 pp.

Waldeyer (W.), "Das Becken." 8°, Bonn, 1899, 600 pp.

Zaaijer (T.), "Der Sulcus preauricularis ossis ilei," *Verh. k. Akad. Wet.*, Amsterdam, 1893, 23 pp.

Preauricular sulcus	Infrequent	More common and better developed
Sacrum	Relatively high and narrow	Shorter and broader, more obliquely set, less curved in upper portion; sacro-vertebral angle more prominent
Pelvis as a whole	Strong, heavy, marked muscular impressions	Less massive, smoother
Brim	Heart-shaped	More circular (or elliptic), more spacious
True pelvis	Relatively smaller	More oblique, shallow and spacious, less encroached upon by ischiac spines

However, none of the above characteristics are wholly constant, and there are pelves so intermediate that a correct diagnosis of sex from them alone cannot be made with certainty.

As to the *long bones*, those of the male are generally larger and heavier than those of the female and have more pronounced muscular ridges, tuberosities and impressions; but the most important and striking sexual differences lie in their articular extremities, which in the bones of the male are in general both absolutely and relatively larger than in the female. A femur or a humerus with a small head or condyles cannot be masculine, neither can bones with relatively large heads or condyles be feminine. These differences are of great help in sexing the skeleton or individual bones. However there are also intermediary grades of development which might leave us uncertain if we had the long bone only.[1]

As to the remaining larger bones of the body, the most important for sexual identification are the sternum, scapulæ, ribs, the spine as a whole, some of the vertebrae such as the atlas, axis, and the fifth lumbar, the patella, the calcaneus, and the first phalanx of the great toe. In general they all show larger size, greater weight and stronger development of muscular attachments in the male; and they present various individual features which differ more or less in the two sexes, such as the relatively longer manubrium in the female, a larger glenoid cavity in the male, etc. Their utilization for sexual identification stipulates naturally a special acquaintance with these various bones.

[1] Consult Dwight (Thos.), "Range and Significance of Variation in the human skeleton," *Bost. Med. and Surg. J.*, July, 1894, 73 et seq.—"The size of the articular surfaces of the long bones as characteristic of sex," *Am. J. Anat.*, 1904, IV, 19–31.

Dorsey (Geo. A.), "A sexual study of the size of the articular surfaces of the long bones in aboriginal American skeletons," *Bost. Med. and Surg. J.*, July 22, 1897.

Even the smaller bones, such as those of the tarsus, may help in this connection.

In addition to the differences due to the general development of bones, various parts of the skeleton occasionally present features as for example perforation of the septum in the humerus, third condyle on the femur, a teres major process of the scapula, etc., which do not occur with the same frequency in the males as in the females; but as they may occur in both, their presence or absence in individual cases is not of decisive value. Furthermore, all the bones of the skeleton when studied in lots will show characteristic sexual differences of anthropometric nature, in absolute dimensions as well as indices; but except in extremes these again are of only secondary value in the case of individual bones.[1]

In subadults, determination of sex is mostly hazardous, nevertheless there are a certain proportion of cases in which it is possible. But as the age descends the difficulties of identification rapidly increase, until when we reach puberty and below, it becomes in general very risky, if not impossible.

Estimation of Age.—A correct estimation of the age of a skeleton is of a much greater medico-legal than anthropological importance; but by mastering the details, for which our science is favorably situated, the anthropologist may occasionally be of substantial aid to legal medicine.

For the anthropologist himself it generally suffices to determine whether the skull or skeleton is subadult, adult, or senile, and his main criteria for these purposes are the state of the basilar suture, that of the epiphyses of the long bones, the stage of dentition, the condition of the teeth and alveolar processes, and the state of the sutures of the vault of the skull.

Of all the marks that the adult stage of life has been reached, the most handy and reliable is the *occlusion of the basilar* (*basisphenoid*) *suture;* and the value of this sign is furthermore enhanced by the rarity with which abnormal processes affect this articulation. But the basi-sphenoid articulation may be opened mechanically, through posthumous changes in the bones or through violence, and the student must be on the lookout not to mistake such a condition, which to the unaided eye may simulate very closely the normal suture, for the latter.

The *epiphyses* of the long (and other) bones are normally all united with their diaphyses by the end of the twenty-fifth year. The following figures give approximations to the exact time of synostosis in the different cases, according to modern Anatomies. They again can be of but a restricted use to the anthropologist.

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[1] See author's "Physical Anthropology of the Lenape," etc., Bull. 62, Bur. Amer. Ethnol., Wash., 1916.

OSSIFICATION (COMPLETED)

		Year		Year
Basilar suture		20–25	Scapula	20–25
Humerus:	upper	20–25	Clavicle, sternal end	25
	lower	18–19	Sternum	20–25
Femur:	upper	18–20		
	lower	20–22	Ribs	25
Tibia:	upper	20–24	Vertebrae	25
	lower	18		
			Atlas	18
Ulna:	upper	16		
	lower	20–23	Sacrum (union of uppermost segments)	25–30
Radius:	upper	17–20		
	lower	20–25	Ossa innominata	20–25
Fibula:	upper	22–25	Phalanges	18–20
	lower	19–20		

The *eruption of deciduous teeth* among Whites is generally completed before the end of the third, that of the *permanent teeth* before the thirtieth year of life. Among primitive peoples (possibly even primitive Whites), the process, at least so far as the permanent teeth are concerned, is somewhat speedier, being with some exceptions accomplished by or even before the twenty second year.[1] A full set of teeth in a skull is therefore a good sign that adult life has been reached, or nearly reached; but an absence of one or two third molars may exist in the white, and more rarely even in a primitive man, well into the adult stage, and such teeth may fail to appear altogether. The following table gives the periods of eruption of both sets of teeth among civilized Whites. On account of the length of the period of eruption of the individual teeth the data will be also of but limited use.

ERUPTION OF TEETH, IN WHITES[2]

1st Dentition	Months	*Permanent Dentition*[3]	Years
Median Incisor, lower	4– 8	First Molar, lower	4– 7
Median Incisor, upper	8–11	First Molar, upper	5– 8

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[1] See Suk (V.), "Eruption and decay of permanent teeth in Whites and Negroes, with comparative remarks on other races," AM. J. PHYS. ANTHROP., 1919, II, No. 4, 352.

[2] After Bean, Bednář, Cherot, Gray, Matiegka and Suk, Roese, Steiner, Vogel, Welcker, etc.

[3] Exact order of eruption of permanent canines and premolars is still slightly uncertain.

	Months		Years
Lateral Incisor, upper	8–11	Median Incisor, lower	5– 8
Lateral Incisor, lower	12–15	Median Incisor, upper	5– 8
First Molar, upper	9–21	Lateral Incisor, lower	6–10
First Molar, lower	12–21	Lateral Incisor, upper	6–10
Canine, upper	16–24	Anterior Premolar, upper	7–14
Canine, lower	16–25	Canine, lower	8–14
Second Molar, upper	20–36	Anterior Premolar, lower	8–15
Second Molar, lower	20–36	Posterior Premolar, upper	9–15
		Posterior Premolar, lower	9–15
		Canine, upper	9–16
		Second Molar, lower	10–17
		Second Molar, upper	10–17
		Third Molar, lower	15–30
		Third Molar, upper	17–30

The pubic articulation shows important changes with age.[1]

A valuable indication as to advancing age is furnished to us by the *wear of the teeth.*[2] In Whites this seldom commences before the thirty-fifth or is marked before the fiftieth year of age, and in many individuals of the more cultured classes it may remain slight up to old age; but among grain-eating, primitive peoples, such as the American Indians, wear may commence even before the adult life has been reached, be very marked at fifty, and reach an extreme grade after sixty-five. Partial wearing, due to peculiar habits, has of course but little value in this connection.

The *obliteration of the cranial sutures* has long been relied upon as a help in estimating the age of the subject, and is useful when taken conjointly with other characters. Under normal conditions, i. e. in subjects who have not been affected by rickets or other generalized pathological processes, synostosis of the bones of the vault does not commence until well after adult life has been reached, and in some individuals some or all of the bones of the vault may remain free until advanced age. On the average, however, we may expect to find some traces of synostosis ventrally about the thirtieth, and dorsally about the fortieth year of life. In view of the difficulties of a proper endoscopic examination, the dorsal signs of obliteration are the only ones with which the anthropologist under ordinary circumstances needs to concern himself. The obliteration here may begin in the posterior third of the sagittal suture, or in the distal portions (below the temporal crests) of the coronal—there are some racial as well as individual differences in this respect. A complete obliteration of the coronal, sagittal, and lambdoid sutures under ordinary conditions is reached only in advanced age, after seventy, and in fact is seldom fully accomplished even then. The temporal articulations, with the exception of that with the occipital, are the last to ossify. A complete synostosis of all the articulations of the bones of the vault at any age would justify a suspicion of some abnormality. With ample experience, and taking the condition of the sutures and teeth together, we may correctly estimate the age of the adult subject to within, perhaps, ten years.[1]

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[1] See Todd (T. Wingate), "Age changes in the Pubic Bone," *Am. J. Phys. Anthrop.*, 1920, III, No. 3, 285.

[2] See Broca (P.), *Bull. Soc. d'Anthrop.* Paris, 1879, S. 3, II, 342; Instructions craniolog., etc., 1875, 132.

As *signs of advanced senility,* may be named a diminution in weight of the skull and bones, with more or less rarefaction of the bone structure (particularly in the long bones of the lower limbs and the spine); extensive loss of teeth and marked absorption of the alveolar processes; and disseminated marginal exostoses of the lumbar and other vertebrae. This latter condition, although usually looked upon as pathological, is so common in senile skeletons of all races that it may well be regarded as a part of the process of skeletal senile involution, becoming only secondarily, or through its irregularities and complications, pathological.

In addition to the above the vault of the skull may in advanced age occasionally show a more or less marked absorption of the bony tissue (diploë) of the parietals above the temporal ridges, with a consequent bilateral, antero-posterior depression. The lower jaw may in instances be reduced to a mere frail shell, with greatly widened angles; while the upper alveolar process may be completely absorbed and the loss involve even a part of the nasal floor. But these extreme manifestations of senile resorption are of little value as indices of the age of the individual in years.[1]

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[1] See in this connection, Dwight (Thos.), "The closure of the cranial sutures as a sign of age," *Bost. Med. and Surg. J.*, 1890, 389.

Frederic (J.), "Untersuchungen ü. d. normale Obliteration der Schädelnähte," *Z. f. Morph. and Anthrop.*, 1906, IX, 273; 1909, XII, 371.

Parsons (F. G.) and C. R. Box, "The relation of the cranial sutures to age," *J. Anthrop. Inst.*, 1905, XXXV, 30.

Pommerol, (J.), "Recherches sur la synostose des os du crâne," *Bull. Soc. Anthrop. Paris*, 1869, S. 2, IV, 502; and Thése, Paris.

Ribbe (F. C.), "Étude sur l'ordre d'oblitération des sutures du crâne dans les races humaines," *Thèse*, Paris, and *Rev. d'Anthrop.*, 1885, S. 2, VIII, 348.

Welcker (H.), "Altersbestimmung der Schädel," *Arch. f. Anthrop.*, 1866, I, 113.

Zanolli (V.), "Studio sulla obliterazione delle suture craniche," *Atti Soc. rom. Antrop.*, 1908, XIV, 13.

Identification of Parts.—Given a series of crania, and perhaps other bones, for examination, we frequently find that some of the lower jaws have become detached from the skulls, and various bones separated from the skeletons to which they belong. We may further find individual crania, or even larger admixture, of a different type from that of the rest of the collection. Our object naturally will be to properly fit the stray parts, and segregate the heterogeneous specimens. This once more demands considerable care and experience.

The fitting of the lower jaw to its skull is fairly easy if we have to deal with only a few specimens; but in larger collections, and even in some individual cases where more or less warping of the lower jaw has taken place, the task may be quite difficult. The main guidance of the student will be the fit of the teeth, the fit of the condyles, the color and mottling of the specimens, and various conditions and peculiarities of the teeth. He will find a similar or compensatory wear of the teeth in the two jaws of the same individual; a correspondence of more or less extruded or unworn teeth (especially the third molar) in one jaw, to absence of opposite tooth in the other; a similar staining of or concretions about the teeth; etc. But there may be anomalies in one (especially the upper) jaw for the counterparts of which he would vainly look in the other.

As to other parts of the skeleton, which may be touched upon in this place, we can only hope to establish whether or not a certain bone belongs to a skeleton in question by its fit with other bones in articulation, and by resemblances in color, size, shape, muscular insertions, processes, and peculiarities, with the corresponding bone of the opposite side of the body. With the exception of the atlas we are never in a position to absolutely identify a given stray bone, or even a whole skeleton, with a given skull. Occasionally we find it difficult to even pair or place individual bones; but special features and measurements help greatly in this direction.

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[1] Consult: Allen (Harrison), "On the effects of disease and senility as illustrated in the bones and teeth of mammals," *Science*, 1897, V, 289–294.

Broussé (A.), "De l'involution sénile," 8°, Paris, 1886.

Féré (C. H.), "Sur l'atrophie sénile symmétrique des pariétaux," *Bull. Soc. d'Anthrop.*, Paris, 1876, S. 2, XI, 423. (cont'd next p.)

Humphry (C. M.), "Senile hypertrophy and senile atrophy of the skull," *J. Anat. and Physiol.*, London, 1890, XXIV, 598.

Le Courtois, "Modifications morphologiques de la voûte crânienne osseuse suivant l'âge et le type crânien," *Bull. Soc. d'Anthrop.*, Paris, 1870, S. 2, V, 607–620.

Pozzi (Senile changes in the skull). *Dict. Encycl. d. Sc. Méd.*, XXII, 492.

Sauvage (H.), "Note sur l'état sénile du crâne," *Bull. Soc. d'Anthrop.*, Paris, 1870, S. 2, V, 576. Also sep., Paris, 1870, 132 pp.

Smith (G. Elliot), "The causation of the symmetrical thinning of parietal bones in ancient Egyptians," *J. Anat. and Physiol.*, London, 1907, XLI, 232.

Thomas (O.), "Notes on a striking instance of cranial variation due to age," *Proc. Sci. Meetings Zoöl. Soc.*, London, 1886, P. I, 125 pp.

Virchow (R.), "Ueber die Involutionskrankheit (Malum senile) der platten Knochen, namentlich des Schädels," *Ges. Abh.*, 1856.

Recognition of distinct racial types in a collection, demands especially careful procedure. The skull of a typical White, a typical Negro, a typical Eskimo, or a typical American Indian, may be readily and reliably identified, wherever found by the expert student; and in a smaller measure this is also true of some other parts of the skeleton. But when it comes to a recognition of crania or bones of mixed-bloods, or of closely related racial types, we face considerable uncertainties. The safest rule in all cases is for the observer to set aside from his series any skull or skeleton concerning the anthropological identity of which he is in serious doubt. He will bear in mind, of course, that among all peoples there exists in every feature a wide range of normal variation.

Determination of Normality.—A normal skull (or a normal bone) is that which has not been modified in shape, size, or any other manner, mechanically or through disease.

Mechanically a skull may be modified through injury, artificial or accidental deformation in life, or posthumous deformation.

Deformations through injury are readily recognizable, and in general are of small importance to anthropology. But extensive injuries of the vault and especially of the face, or injuries followed by serious alterations in the bone, may spoil the specimen more or less for study.

Artificial and accidental deformations in life have been dealt with previously (pp. 47–8), and the observations made in that connection apply essentially also to the skull. The best way to appreciate lesser grades of deformations is to pass the hand snugly over the top of the skull from before backwards; the practiced sense of touch is even more reliable in these cases than the sense of sight, and will be of much assistance.

Posthumous deformations are fortunately not frequent, but must nevertheless be reckoned with, and that above all in imperfect skulls and with the lower jaw. The degree of such deformation, with or even without fracture, is sometimes remarkable. As a result the vault of a skull may assume extreme steno-dolichocephalic or plagiocephalic appearance, and the arch of the lower jaw be considerably compressed—conditions which could easily deceive the inexperienced.[1] Posthumous deformations of the long bones may simulate curvatures; in other parts they are immaterial.

Deformations caused by disease[2] are most commonly those of rickets, or hydrocephalus. Microcephaly, akromegaly, diffuse osteoporosis, and leontiasis ossea, each represent or may produce marked alterations in the shape, size, weight, and individual features of the skull. But recognition of these conditions when well developed offers no difficulties. The bones of the skeleton may be altered through dwarfism, cretinism, giantism, acromegaly, syphilis, inflammations, tumors, osteomalacia, tuberculosis, and above all, as already mentioned, by rachitis.

MEASUREMENTS OF THE SKULL

As for measurements on the living, so for those on the skull, the observer needs a well-lighted place and one where he will be least disturbed. He will need ample table space, which, however, may in part be improvised with boards. He should have at hand a camera, a stereograph or some other form of large drawing apparatus, and a mounted prism ("camera lucida"). He will need a suitable stuffed leather or canvas ring as skull support. And, as in work on the living, he will need properly prepared blanks (fig. 18, p. 119).

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[1] See Tarenetzky (A. J.), Postmortem alterations and damage of skulls (in Russian) *Proc. Anthrop. Sect. Milit.-Med. Acad.* St. Petersb., 1895, I, 19.

[2] See Backman (G.), "Ueber die Scaphocephalie," *Anat. Hefte,* H. 112, Wiesbaden, 1908, 219–270 (with extensive bibliography).—"Ueber Bathro- und Clinocephalie," *Ibid.*, H. 140, 1912, 495–571 (Bibl.).

Bogtstra (J. N.), "De Schedel met ingedrukte Basis," Leiden, 1864, 44 pp.

Broca (P.), "Instructions craniologiques, etc.," Paris, 1875.

Davis (J. B.), "On synostotic crania among aboriginal races of man," *Natuurk. Verhandl. d. Wet. t. Haarlem*, 1865, XXII, 59 pp.

Frassetto (F.), "Appunti sulla scafocefalia patologica," *Atti Soc. Rom. di Antrop.*, 1905, XI, 18 pp.—"Appunti sulla trigonocefalia," *Ibid.*, 7 pp.—"Appunti sulla 'oxicephalia,'" *Atti Cong. Natur. Ital.*, 1907, 8 pp.

Grawitz (P.), "Beitrag zur Lehre von der basilaren Impression des Schädels," *Arch. f. pathol. Anat.*, LXXX, 449–474.

Huschke (E.), "Ueber Cranioscierosis totalis rhachitica und verdickte Schädel überhaupt," 4°, Jena, 1858.

Knox (R.), "The cranium," *Contr. to Anat. and Physiol.*, repr. fr. London Med. Gaz., 1842–3, II, 6–9.

Manouvrier (L.), "Étude craniométrique sur la plagiocéphalie," *Bull. Soc. d'Anthrop. Paris*, 1883, VI, 526–553. ——, and E. Chantre, "La dolichocéphalie anomale, etc.," *Bull. Soc. d'Anthrop. Lyon*, 1886 (repr. 14 pp.).

Pommerol (F.), "Recherches sur la synostose des os du crâne, considérée an point de vue normal et pathologique chez les différents races humaines." Thèse, Paris, 1869, 116 pp.

Virchow (R.), Gesam. Abh., 1856.

The specimens to be examined are separated first according to kind, then according to sex, and are then arranged by numbers. All of this facilitates work.

The blanks should be based on the same general principles as those for measurements and observations on the living (see p. 63 et seq.). Separate blanks are required for the skulls and for each kind of bone. To save work these blanks may be printed; or they may be prepared on good sized sheets marked in squares large enough to readily accommodate the records either in figures or in abbreviations. Sample blanks are given on the following page.

Selection of Measurements.—The same general rules that apply in this respect to the living (p. 61) apply also to the skull and rest of the skeleton and need not be repeated here. The skeletal collections, however, are for the most part fully and continuously at our disposal, so that they may be used again and again, serving for a series of studies besides that the object of which was a general description. The student may thus in cases require but a single measurement, or a special observation on a single feature of a skull or a bone, and he will prepare his scheme to suit the occasion.

When the object is a general description of a series of crania (or skeletons), the observer will naturally endeavor to show first those features which are of the greatest importance from the standpoint of race or group; and these are usually the size, shape, and peculiarities of the specimen as a whole, and in its main parts. In the case of the skull, he will therefore measure the principal dimensions of the vault, with its capacity; the main dimensions of the face, lower jaw, palate and teeth; and take notes on the form of the vault, face, nose and orbits. He will add such visual observations as may complete in all essential points the picture of the specimen which he wishes to transmit so that this may be properly conveyed to his fellow workers and used in comparison. The concrete object of the work, as here touched upon, should not be forgotten in the maze of details. A list of measurements and observations used for these purposes by the author, is here given:

Instruments.—Craniometry, as well as osteometry, has a series of its own instruments. The small sliding compass (c. glissière), the regular spreading calipers (c. d'épaisseur), and the anthropometric

———————————— *Crania.* A.

Sex:————

Catalogue No.	Collection	Locality	Approximate Age of Subject.	Deformation	Vault							Capacity in c.c. (Hrdlička's Method)	Thickness of Left Parietal 1.0 cm. above T.-P. Suture
					Diam. Antero-posterior maxim.	Diam. Lateral maxim.	Basion-Bregma Height	Cranial Index	Mean Height Index $\frac{H}{\text{mean of } L+B}$	Cranial Module			

———————————— *Crania.* B.

Sex:————

Catalogue No.	Diameter Frontal min.	Face					Base				
		Menton-Nasion Height (*a*)	Alveolar Point-Nasion Height (*b*)	Diam. Bisygomatic maxim. (*c*)	Facial Index, Total $\left(\frac{a\times 100}{c}\right)$	Facial Index, Upper $\left(\frac{b\times 100}{c}\right)$	Basion-Alveolar Point (*x*)	Basion-Subnasal Point (*y*)	Basion-Nasion (*z*)	Facial Angle (Angle between *z* and Alveolar Point-Nasion Line)	Alveolar Angle (Angle between *z* and Alveolar Pt.-Subnas. Pt. Line)

———————————— *Crania.* C.

Sex:————

Catalogue No.	Nasal Apperture			Orbits			Palate			Lower Jaw				Miscell.		Arcs			
	Height	Breadth Maxim.	Nasal Index	Height, Right, Left,	Breadth, Right, Left,	Orbital Index, Mean	External Length (*a*)	External Breadth, maxim. (*b*)	Palatal Index $\left(\frac{b\times 100}{a}\right)$	Diam. Bigonial	Angle of Lower Jaw, mean	Height of Symphysis	Thickness of Horiz. Ramus bet. 1 & 2 Molars r. l.	Foramen Magnum, Mean Diam.	Circumference maxim. (Above Ridges)	Nasion-Opisthion	Nas.-Bg.	Bg.-Lda.	Lda.-Opisth.

tape, are the same as for measurements on the living; but in addition the student will need an outfit for measuring the skull capacity; one for drawing; a Broca's mandibular goniometer; a transparent goniometer; and instruments for special purposes, such as the occipital goniometer, small sharp pointed calipers, an endocompass, curved brass probe, etc. For measurements on other bones of the skeleton he will need, in addition, the standard osteometric board with a block, a pelviphore, and apparatus for measuring the torsion of the humerus. With a few exceptions, these appliances are described and illustrated in Broca's "Instructions Craniologiques et Craniométriques" (Paris, 1875); in Topinard's "Éléments d'Anthropologie Générale" (Paris, 1885); in Martin's "Lehrbuch der Anthropologie" (Jena, 1914); and in Mathieu's, Collin's, and Hermann's Catalogues of anthropometric instruments. As far as additional description or remarks may be called for, they will be made most suitably in connection with the individual measurements.

Landmarks.—Before proceeding to the description of methods, it will be useful to give a list of the landmarks on the skull and their definitions. We may here conveniently draw on Topinard's and Martin's textbooks and on Cunningham's and other modern Anatomies, which include lists of this nature; but it may be of some advantage to give the terms in alphabetical order, and in a few instances to supplement the definitions.

Alveolar Point (*or Prosthion*).—The term "alveolar point" has a long priority of usage and no valid reason is apparent why it should be changed. It is the lowest point of the upper alveolar arch, between the median incisors. Broca defined it as the lower extremity of the intermaxillary suture, but occasionally the bone on one side or the other projects slightly beyond the suture, so that the above definition is preferable.

Asterion.—The point of meeting of the temporo-parietal, temporo-occipital and lambdoid sutures.

Basion.—The middle of the anterior margin of the foramen magnum.

Bregma.—The point of junction of the coronal and sagittal sutures.

Dacryon.—The point of junction of the lachrymo-maxillary, fronto-maxillary and fronto-lachrymal sutures.

Glabella.—A point midway between the two supraorbital ridges.

Gonion.—Point of the angle formed by the ascending branch with the body of the lower jaw.

Gnathion.—See Menton.

Inion.—The most prominent point of the external occipital protuberance. (Now of secondary importance. In some specimens the protuberance may be absent; rarely it may be double with a depression between; and in instances it may be wholly replaced by a depression.)

Lambda.—The meeting point of the sagittal and lambdoid sutures. (Often displaced by Wormian or other intercalated bones.)

Maximum Occipital Point.—The point on the squamous part of the occipital most distant from the glabella.

Menton ("Point mentonniére," "Gnathion").—The lowest point in the middle of the bony chin.

Nasion.—The median point of the naso-frontal suture.

Obelion.—A point on the sagittal suture on a line with the parietal foramina. (When both foramina are absent, the point may be estimated by comparison with other skulls.)

Ophryon.—The central point of the smallest transverse diameter of the forehead, measured from on temporal line to the other. (Obsolete.)

Opisthion.—The middle of the posterior margin of the foramen magnum.

Pogonion.—The most prominent point of the bony chin.

Pterion.—The spheno-parietal (or fronto-temporal, when that form exists) articulation.

Subnasal Points.—The lowest point, on each side, on the lower border of the nasal aperture, *i. e.*, the lowest points anteriorly of the two nasal fossae. (If simian gutters are present, the subnasal points may be located on the lines limiting anteriorly the floor of the nasal cavity, or their location may be impossible.)

Stephanion.—The point where the coronal suture crosses the temporal line. (Obsolete.)

Vertex.—The summit of the cranial vault.

METHODS.

As with measurements on the living, so with the skull and the rest of the skeleton, our foremost and most binding authority are the International Agreements (q. v., p. 50 et seq.). But as in that case so here the directions may in places be amplified so as to aid the student and prevent misconceptions. More or less obsolete measurements, on the other hand, may well be excluded, for the object of this treatise is to deal with the essential parts, rather than with the entire large field, of anthropometry.

THE VAULT

Maximum length: The maximum glabello-occipital diameter of the vault. Instrument: *c.e.*,[1] any pattern.

Method: As specified by International Agreements (p. 14) and on the living (p. 68).

Maximum breadth: The greatest transverse diameter of the vault above the mastoids and roots of zygomae. Instrument: *c. e.*

Method: As specified by I. A. (p. 14) and on living (p. 69).

Basion-bregma height.—c. e.

Method: Place left forefinger in foramen magnum, press ball of finger lightly against anterior border of the foramen, apply one point of compass so that it rests on the lowermost point of the border in the middle and against the finger, apply other point to bregma, and read measurement. Or, apply point of right branch of compass to bregma and bring point of left branch to basion.

Remark.—The maximum height of the vault is less desirable than the basio-bregmatic, because used by fewer observers, and on account of the not infrequent thickening and ridging of the bone in the sagittal region.

Thickness: Thickness of left parietal, 1 cm. above and along the squamous suture.—*c. e.*

Method: Introduce one branch of compass into the cranial cavity, apply to anterior part of the lower portion of the parietal approximately 1 cm. above the squamous suture, bring other branch in contact with the bone externally, and pass backwards at about the same distance from the sutures, watching the scale of the instrument. Record observed minimum and maximum. These give a mean which is useful for comparison, and which must be taken account of in estimates of skull capacity from external dimensions.

Minimum frontal diameter.—c. e. or *c. g.* Landmarks and method as given by the I. A. (p. 16).

Capacity.—This measurement, corresponding closely to the volume of the brain, is one of considerable importance, and as it is also beset with difficulties it demands special attention.

An ideal method of obtaining the capacity would be by some liquid, water or mercury, which could be easily and directly measured; but attempts at such a procedure have met thus far with unsurmounted difficulties due to the porosity of the bones, the numerous canals and foramina, and the sharp processes on the inside of the skull.

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[1] Compas d'épaisseur.

The various older methods of measuring cranial capacity may be segregated into five groups, namely:

1. The skull is made impermeable and after that filled with some liquid, preferably water, which is then weighed or measured; or the water is forced into a thin rubber bag until it fills with this the entire skull cavity, after which the liquid is measured. These methods, employed by Broca, Schmidt, Matthews, etc., yield good results, but are too complicated or tedious for ordinary use.

2. The skull is filled with sand or other substances, and this is weighed, the result giving a basis for calculating the capacity. This method, used especially by some American anthropologists of the last century, was not sufficiently accurate, and soon became obsolete.

3. The skull is filled with small, rounded seeds, beads, shot or other substances, and the contents are then measured (Tiedemann, Busk, Flower, etc.). The filling or the measuring (or both) is aided by certain manipulations (tilting, tapping, etc.), but, except the measuring vessels, no implements are required. The method in its numerous modifications is comparatively easy and has other advantages, but the results are mostly not as accurate as desirable.

4. The method invented and regulated by and named after Broca. In this procedure the skull is packed with shot, which is then measured; but both the filling and measuring are aided by certain implements, and every step of the procedure follows definite rules. Among the implements used appears a funnel of certain dimensions, which controls the flow of the shot. The method gives steady results, but can not be used with frail skulls, and the capacity obtained is always larger than actual, the proportion growing with the size of the skull.

5. Welcker's method.[1] In this procedure, which is the outgrowth of the majority of those mentioned, but more directly of that of Broca, the most important part is delegated to the funnel, which, by its size, controls the measuring of the contents of the skull. The mode of filling the skull, so long as efficient and uniform, is immaterial; all that is required is that each worker should, with the aid of a standard skull, find the exact size of the funnel necessary to give him, in measuring, the correct result with his particular method and substance used for the filling of the skull. Any rounded seed or substance can be em-

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[1] *Arch. f. Anthrop.*, Bd. XVI, S. 1 et seq. E. Schmidt, "Anthropologische Methoden," pp. 217–219. A modification of the instruments with a form of a funnel stopper has been proposed independently of the author by E. Landau, *Intern. Centralbl. f. Anthrop.*, etc., 1903, I, pp. 3–7.

ployed for the filling, as it is possible to completely fill the cranial cavity without using the process of jamming, such as that used by Broca; this allows the most fragile skull to be measured without any injury. Welcker advocated a funnel large enough to receive all the contents of the skull. The contents of the properly filled skull are emptied into a separate vessel and then "with one movement is versed into the funnel," which is open (not provided with any stopper) and held in position vertically and centrally above the graduated receiving vessel. Each new series of measurements is controlled by the standard skull.

The author's method, in use since 1901,[1] is a modification of Welcker's. It is based on the observations, that: (*a*) The same substance poured through the same funnel with the same rapidity will always give the same, but with different rapidity will give differing, measures; (*b*) each different substance that can be utilized for the measurement of cranial capacity, flowing through a definite size of funnel and with regulated rapidity, will give different results from those given by any other substance flowing through the same funnel and with equally regulated rapidity. (*c*) Given the same regulation of rapidity of the flow, there can be obtained, through the proper selection of funnels of different diameter, any measurement, ranging between the minimum and maximum of a substance of medium weight and size, by all the solid substances employable for filling the cranial cavity.

Efficient regulation of the flow of the substance used was obtained by adding to the funnel a movable stopper. By doing this, it becomes immaterial as to with what rapidity, or in what manner, the funnel is filled before opening the stopper. This removes at once all source of error connected with the emptying of the cranial contents, and allows us to dispense with the extra vessel used in measuring the cranial contents in Welcker's procedure. With the funnel closed, the cranial contents are poured into it entirely at the convenience of the measurer.

The apparatus used is shown in Fig. 17. The mode of filling the skull is that used by Flower. To measure the contents, they are emptied directly, in any way desired, into a combination of a zinc vessel (higher than, but otherwise similar to, the standard Broca's double liter) and a removable funnel of 45° dip, with 15 mm. high vertical section, which, for my purpose (using old, dry mustard seed) is 20 mm. in diameter. Immediately below the funnel is a movable disk which acts as its stopper. The disk is attached to a rod which rises along the side of the vessel and above its border, and ends in a lever; by using this lever the disk closes or opens the funnel. A number of extra funnels, of the same dip but of different sizes, are provided, from which to choose if another substance than mustard seed is used for the filling. The vessel with the cranial contents is placed on the top of a 2,000-c.c. graduated glass tube (such as used by Ranke), which is fixed in a vertical position. The zinc vessel is provided with a groove in its bottom which exactly fits the border of the glass, the opening of the funnel being central. Then the lever is rapidly pushed to either side, opening the funnel at once and completely, and the flow left to itself; the level which the seed reaches (determined simply by the eye or, preferably, the careful aid, without any shocks or pressure, of a niveau finder, such as comes with Ranke's tube) is the skull capacity. The measuring part of the capacity determination is thus reduced to a mechanical procedure, which not only makes it easy, but eliminates from it practically all source of error due to personal equation. What the student needs to learn is some method by which a complete and uniform filling of the skull can be effected, and then, working with the aid of standard

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[1] Described in *Science*, 1903, 1011–14.
Published originally in *Science*, 1903, 1011.

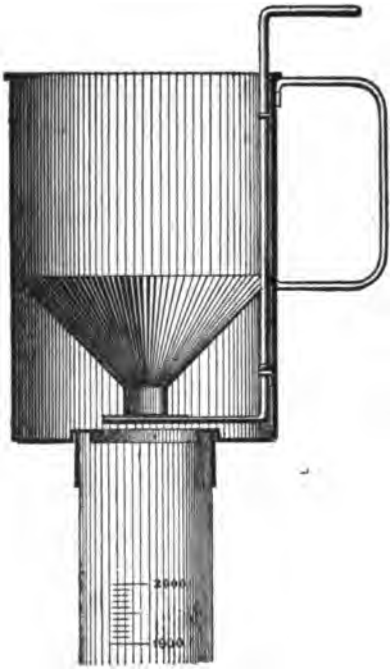

Fig. 17. Hrdlička's apparatus for measuring cranial capacity.

skulls, choose the proper funnel; the rest is controlled. The results, always with the condition that the proper use is made of the standard skulls, are as uniform and as near the reality as can be reasonably hoped for.[1]

FACE

Menton-nasion height (or "*nasion-menton diameter*").—*C. e.*, or *c. g.*

The distance from menton to nasion, with the lower jaw in place and the teeth in apposition. Note condition of teeth, especially as to wear.[2]

Alveolar point—nasion height (or "*naso-alveolar diameter*").—*C. g.*, or *c. e.*

Landmarks.—See I. A. (p. 16).

Maximum bizygomatic diameter.—*C. e.*, or *c. g.*

Landmarks, etc.—See I. A. (p. 16).

BASE

Basio-alveolar diameter.—*C. e.* or *c. g.*

Distance between basion and the alveolar point.

Basion-subnasal point diameter.—*C. e.*

Distance between basion and the left subnasal point.

The triangle basion-alveolar point—subnasal point-basion gives the measure of alveolar prognathism, which it is useful to show separately from the facial prognathism.

Basion-nasion.—*C. e.*

Distance between basion and nasion. The angle between the basion-alveolar point line and that from the alveolar point to nasion, gives the facial angle, which is the expression of the combined alveolar and facial prognathism.

NOSE

Nasal height.—*C. g.*

Landmarks: As given by I. A. (p. 16).

Method: Measure to base of spine, or separately to each subnasal point and record the mean.

Nasal breadth.—*C.g.*

Landmarks and *Method:* As given by I. A. (p. 17).

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[1] The apparatus is not made for the market, but it should not be difficult for any one to have it constructed by following the given directions.

[2] The question as to whether to allow for the wear of the teeth, when this is present, or not, has not as yet been decided. Until a definite international rule is established, it seems best to record both the actual measurement, and an estimate of what the latter would be with teeth in normal condition.

ORBITS

Orbital breadth.—C. g.

Landmarks and *Method:* As given by I. A. (p. 17).

Orbital height.—C. g.

Landmarks and *Method:* As given by I. A. (p. 17).

UPPER ALVEOLAR PROCESS ("PALATE")

Breadth.—C. g.

Length.—C. g.

Landmarks and Methods: Follow I. A. (pp. 17, 18).

LOWER JAW

Bigoniac breadth.—C. g.

The diameter between the most distal points on the external surface of the angles of the jaw.

Method: Use stub branches of the compass. Apply instrument so that the rod rests on each side against the ramus ascendens, while the branches are brought to the most prominent points about the angles of the jaw.

Angle of lower jaw.—Broca's mandibular goniometer.

Method: See I. A. (p. 21).

Note: The angle differs in general on the two sides of the jaw. The logical procedure is to measure the angle on both sides and record the mean.

Height of symphysis.—C. g.

Height of the body of the lower jaw.—C. g.

Maximum thickness of the body of the lower jaw.—C. g.

Landmarks and Method: As given by the I. A. (p. 20).

Note: To obtain the thickness, measure same on both sides and record the mean (if marked difference is found, individual measurements may also be given). The instrument should be held so that the midline of the teeth (antero-posteriorly) corresponds to the midpoint of the rod of the compass between the two branches.

MISCELLANEOUS

Maximum Circumference.—A. t.

Landmarks and Method: As given by the I. A. (p. 19).

Sagittal arc.—A. t.

Landmarks and Method: As given by the I. A. (p. 18).

Note: If subdivisions of the arc are to be recorded, include only those specimens in which there are no intercalated bones at bregma or lambda.

VISUAL OBSERVATIONS

As in the case of measurements, so in that of visual observations. only those will be included in the scheme presented here which are of more than casual importance, and which are needed if the observer is to transmit, or the student receive, a well-rounded impression of the specimen or series examined. On special occasions other observations may become of importance and may then be included in the general scheme, or be carried out separately.

A well organized system of observations renders work easier, more rapid, and more accurate. The main care to be exercised by the student in this connection is that his standards correspond as closely as possible to those generally accepted or understood; and in the report on his work he should invariably include brief but clear explanatory statements as to his use of terms and standards. In recording, all unnecessary details should be avoided. Observation blanks are given below.

The subsequent notes will be of assistance in recording the visual observations. They are given in the same order as followed in the blanks. In recording, for "average," "medium," "ordinary," "normal," use always the sign +; for other characters use abbreviations. Rare features deserve separate and comprehensive description.

NOTES

Pathological: Under this term are included injuries, signs of disease, and pathological exostoses, but no morphological abnormalities.

VAULT: *Form from above* (Norma superior)—Main types: Ovoid, pentagonal, elliptical—short, medium or long; rotund.

Supraorbital ridges: Traces, slight, moderate; medium (+, feminine, masculine); pronounced; excessive; neanderthaloid arch.

Mastoids: Small, moderate or submedium, medium (+), large, excessive; peculiarities.

Forehead: High, medium (+), or low; vertical, slightly, moderately or markedly sloping; eminences reduced to one central, or unduly bulging; assymetry (slight or marked); overhanging (hydrocephalus). Metopic suture; metopic ridge.

SAMPLE BLANKS:

CRANIA—OBSERVATIONS

Sex——

Cat. No.	Patho-logical	Vault						
		Shape from above (Norma Superior)	Supra-orbital Ridges	Mastoids	Forehead	Sagittal Region	Temporo-Parietal Region	Occiput

CRANIA—OBSERVATIONS (*continued*)

Sex——

		Sutures				Face	
Temporal Crests	Occipital Crests	Serration	Synostosis (Externally)	Anomalies	Pterions	Prognathism: (*a*) Facial (*b*) Alveolar	Orbits

CRANIA—OBSERVATIONS (*continued*)

Sex——

			Nose			Palate		Base
Malars	Zygomæ	Suborbital Fossæ	Nasal Bones	Spine	Lower Borders of Aperture	Form	Peculiarities	Foramen Lacerum Medium

CRANIA—OBSERVATIONS (*continued*)

Sex——

			Lower Jaw		Teeth			
Depression of Petrous Parts	Styloids	Special	Chin	Peculiarities	Dentition	Wear	Decay	Special and Anomalies

Sagittal region; Under normal conditions, from side to side, oval, moderately or markedly elevated (keeled).

Temporo-parietal region: Parietal eminences may be indistinct, medium, or prominent; temporal region may be flat, medium, or bulging.

Occiput: Assymetry? Flattening? If undeformed: convex, moderately protruding, markedly protruding.

External occipital protuberance: absent, moderate, pronounced, double; iniac fossa.

Temporal crests: State nearest approach to sagittal suture; and whether or not extending over the lambdoid suture on to the occipital.

Occipital crests: Absent, slight, moderate, well developed, pronounced.

Sutures: Serration—none, slight, medium, complex (terms based on conditions in average skulls of Whites). Student may also refer to given standards (Broca, Martin), but above terms when used with proper care are quite sufficient. *Synostosis:* State briefly location, and percentage of suture involved. *Anomalies:* Abnormal sutures—give location and extent. Intercalated bones—state briefly location, nature, number; in more important cases give separately size and other particulars.

Pterions: Give type (H, K, X, I); breadth, if special; note epipteric bones; watch for possible anomalous sutures in wing of sphenoid.

FACE: *Prognathism,* facial and alveolar—none, slight, medium (+), above medium, pronounced.

Orbits: Borders sharp or dull; note important anomalies.

Suborbital fossae: Slight convexity instead; or, concavity slight, medium (+), pronounced.

Malars: Size—submedium, medium (+), large; protrusion—slight, submedium, medium (+), marked. Watch for partial and complete malar sutures.

Zygomæ: Strength: Slender, moderate, strong, massive.

Nose: Nasal bones—narrow, medium (+), broad; anomalies.

Nasal spine: Absent (may even be groove instead), diminutive, medium (+), pronounced; when small may be bifid.

Lower borders of nasal aperature: Sharp, dull; simian gutters—moderate or pronounced; subnasal fossae—small, moderate, large. Assymetry.

Palate: Form—elliptic, ovoid, U-shaped, rotund, horseshoe-shaped. Shallow or high. Torus. Marked remnants of or complete intermaxillary sutures.

BASE: *Foramen lacerum medium:* Of evolutionary and developmental importance.[1] May be small, submedium, medium, or spacious.

Depression of Petrous Parts: Of evolutionary and developmental importance.[1] The depression is in relation to the inferior surface of the basilar process. The petrous portions may be slightly above the level of the process, or present a slight, medium (+), or pronounced depression below the plane of the basilar process (as viewed with the base facing the observer).

Styloids: Absent, diminutive, small, medium (+), excessive.

Special: The base offers numerous anomalies, such as pterygo-spinous foramina, defects in the floor of the auditory meatus, basilar fossa, pharyngeal canal, great inequalities of the jugular canals, various anomalies about the foramen magnum—basilar spine, third condyle, pre-condylar processes, rudimentary atlas, accessory articular facets, paroccipital (paramastoid) processes, etc. In view of the multiplicity of these features it is best to make a special examination for those the observer may wish to report upon.

LOWER JAW: *Chin*—pointed, rounded, square; receding, vertical, slight, medium or marked protrusion. *Peculiarities:* Report extraordinary features of importance.

TEETH: *Dentition:* In children and adolescents note all teeth erupting or erupted. Teeth of first and second dentition must be carefully distinguished. *Wear:* None, slight, moderate, marked, excessive. *Decay:* Note number of teeth lost through or affected by decay. *Special and Anomalies:* Ventral surface of upper incisors may be marked by shovel-shaped concavity with pronounced rim, which is characteristic of the American Indian, occurs occasionally in other yellow-brown people, but is rare or less frequent in other races. In line of dental irregularities and anomalies note crowding, impactions, congenital defects of eruption, supernumerary teeth, and abnormalities of individual teeth. A study of the cusps, as well as that of the form and size of the teeth, is best carried out separately.

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[1] See Hrdlička (A.), "Certain Racial Characteristics of the Base of the Skull," *Science*, 1901, XIII, 309; also *Proc. Assoc. Amer. Anatomists*, 15th Session, *Amer. J. Anat.*, 1901–2, I, 508–9.

OSTEOMETRY

Anthropometry of the skeletal parts (outside of the skull) is a fertile and fascinating field in which much as yet remains to be exploited and even explored. It is, moreover, a large field, which few workers may hope to cover in its entirety. Every bone of the body presents sexual, racial and individual variations, many of which remain to be thoroughly studied; and some of these features, according to indications, possess a very considerable phylogenetic and racial importance.

Investigations on the skeleton are for the most part of a more recent date than those on the skull or those on the living, and have been largely the work of anatomists. Descriptive observations, such as those on the sexual characteristics of the pelvis, or those on the perforated humerus, pilasteric femur, platycnaemic tibia, etc., preceded and accompanied measurements. The first serious attempts at osteometry were made essentially in France, and the first system of measurements was developed by Broca and his pupils in Paris.[1]

Since the early seventies a whole series of valuable contributions to the subject of bone study and osteometry have been made,[2] and much work in this line, particularly in the United States, is as yet unpublished. The repeated discoveries of skeletal remains of early man have in particular stimulated research in this direction. Notwithstanding all this, however, we are still far from a satisfactory grasp of the evidence which the bones embody. The reasons are, in the first place, that the gathering of skeletal material has always lagged behind that of the skulls, so that even today most anthropological collections are relatively poor in that respect, which hinders comprehensive and conclusive investigations. Besides this, the bones of the skeleton present many features and correlations the study of which demands large series of specimens, and in many cases also the presence of all the important constituents of the skeleton or the bones of the two sides of the body, conditions which are realizable with difficulty even among the Whites, not to speak of other peoples. The field will long remain, therefore, one of a very considerable importance, and no pains should be spared to develop the technique of osteological investigation.

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[1] See Broca (P.)—Sur les proportions relatives du bras, de l'avant bras et de la clavicule chez les Nègres et les Européens. *Bull. Soc. d'Anthrop.* Paris, 1862, III, 162–172; ibid., 1867, 2 Sér., II, 641–653. Hamy (T.)—Recherches sur les proportions du bras et d'avant-bras aux differents âges de la vie. *Rev. d'Anthrop.* Paris, 1872, 79. Topinard (P.)—*Éléments d'Anthropologie générale*, 8°, Paris, 1885.

[2] Bello y Rodriguez (S.)—Le fémur et le tibia. *Thèse*, Paris, 1909. Bumüller (J.)—Das menschliche Femur. *Phil. Diss.*, München, 1899. Bertaux (T. A.)—L'humerus et le fémur considérés dans les espèces, dans les races humains, selon le sexe et selon l'âge. *Thèse*, Lille, 1891. Fischer (E.)—Die Variationen an Radius und Ulna des Menschen. *Z. f. Morph. & Anthrop.*, 1906, IX, 147. Lehmann-Nitsche (R.)—Ueber die langen Knochen der südbayerischen Reihengräberbevölkerung. *Phil. Diss.*, München; and *Beitr. z. Anthrop., & Urgesch. Bayerns*, 1894, XI, H. 3 & 4. Livon (M.)—De l'omoplate. *Thèse Méd.*, Paris, 1879. Hrdlička (Aleš)—Physical Anthropology of the Lenape or Delawares, and of the eastern Indians in General. *Bull.* 62, Bur. Am. Ethnol., Wash., 1916. Pfitzner (W.)—Beiträge zur Kenntniss des menschlichen Extremitätens-skeletes. *Morphol. Arb.*, 1892, I, 516; 1893, II, 93. Rollet (E.)—La mensuration des os longs des membres. *Thèse méd.*,

The scheme here presented rests on the same principles as those presented before for anthropometry and craniometry. It utilizes the most useful procedures of other scholars, supplements these where extensive individual experience warrants, leaves aside everything superfluous or of value only in special studies, and aims at the utmost simplicity.

INSTRUMENTS

The matter of osteometric instruments has already to some extent been dealt with in the section on Craniometry (Vol. II, 1919, p. 50). The essentials are few. They are the Broca's osteometric board (pl. 1), the small *compas glissiere* and for a few measurements also the large sliding compass; but other instruments may be needed for special investigations.

Lyon, 1889; *Intern. Monatschr. f. Anat. & Physiol.*, 1889, VI, 345. Soularue (M.)—Recherches sur les dimensions des os et les proportions squeletiques de l'homme. *Bull. Soc. d'Anthrop.* Paris, 1899, Sér. 4, X, 328. Turner (Sir Wm.)—Report on the human crania and other bones of the skeletons collected during the voyage of H. M. S. Challenger, 1873–6: II—The bones of the skeleton. *Challenger Reports*, Zool., 1886, Pt. XLVII. Verneau (R.)—Le bassin dans les sexes et dans les races. *Thèse Méd.*, Paris, 1875. Volkov (Th.)—Variations squelettiques du pied chez les primates et dans les races humaines. *Bull. Soc. d'Anthrop.* Paris, 1903, Sér. 5, IV, 622; 1904, V, 1, 201. Waldeyer (W.)—Das Becken. Bonn, 1899. Wetzel (G.)—Volumen und Gewicht des Knochens als Massstab für den phylogenetischen Entwicklungsgrad. *Arch. f. Entw. d. Organismen.* 1910, XXX, 507–537.

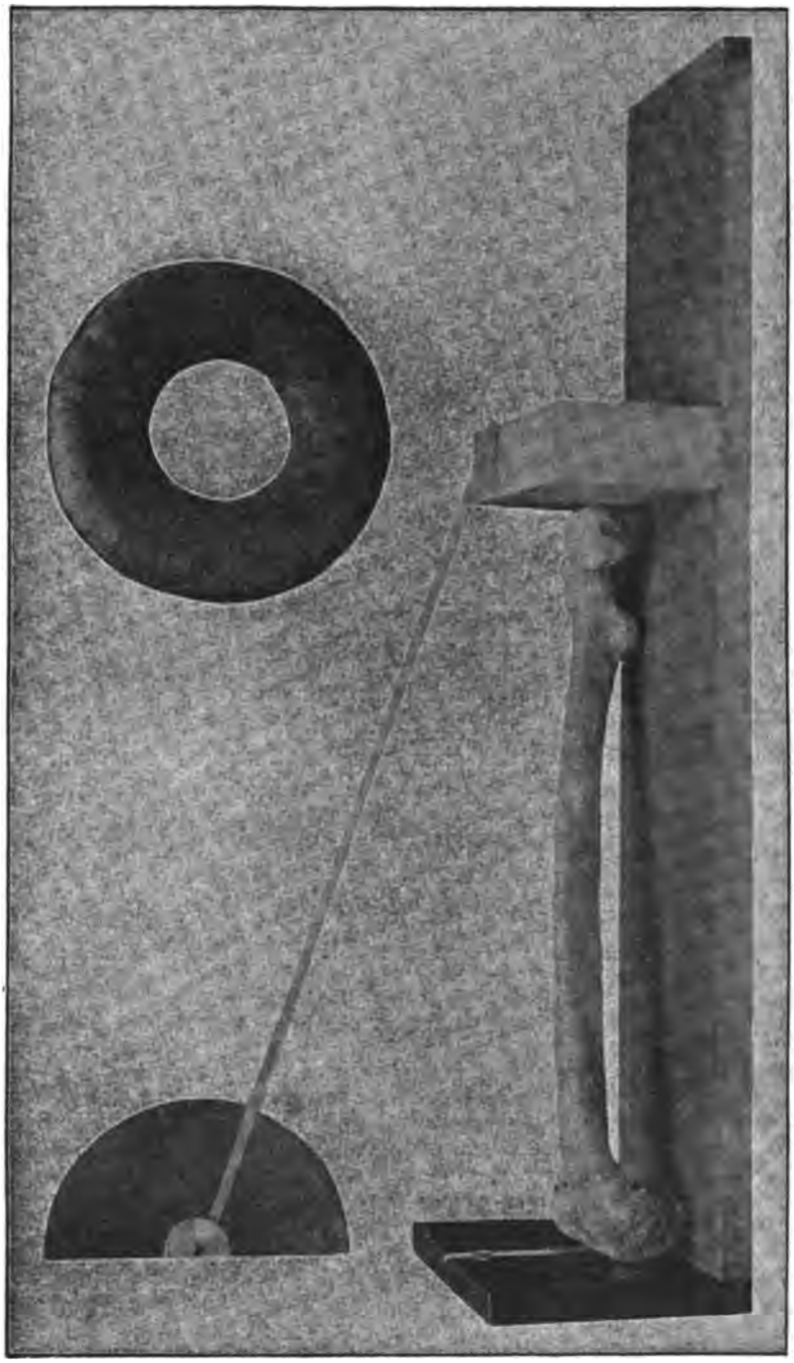

FIG. 18. Osteometric board with block; goniometer (translucent); leather ring, for support of skulls while being measured and examined.

The osteometric board is too well known to need special description; but for the original accessory square the writer uses a block of light wood (see fig. 18), which offers certain advantages. The block is 9.5 cm. high and 4.5 cm. thick, while its length equals the breadth of the board.

For description of instruments used on special occasions the student should consult the original sources.[1]

BLANKS

The matter of blanks in osteometry presents some difficulties on account of the many distinct bones each of which requires its own blank. An outline of a blank such as used for general purposes by the writer will be given separately with each bone. Such blanks may be made by the student himself, and their scope may be enlarged as demanded by the needs of the occasion. As they are they represent what invariably we should know of each of the bones.

OBSERVATIONS: TYPICAL BONE VARIANTS IN FORM

Before proceeding to the measurements, attention should be given to the important subject of bone variations in shape.

Each of the long bones, and also the scapulæ, first rib, etc., present a variety of forms which are reducible to definite types, and the frequency of these types differs from race to race. In the remainder of the skeletal parts similar variations occur, but they are less classifiable. The whole subject is of very considerable anthropological and phylo- as well as ontogenetic importance.

In the long bones the part that varies most in form is the shaft;[2] in the scapula it is in the contour of the bone. Bones of less consequence will be considered on other occasions.

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[1] Besides the Memoirs of Broca and the textbooks of Topinard and Martin, see: Emmons (A. B.)—A study in the variations of the female pelvis. *Biometrica*, 1913, IX, 34–57. Garson (G.)—Pelvimetry. *J. Anat. & Physiol.*, 1882, XVI, 106–134. Frassetto (F.)—Lezioni di anthropologia, 1911–1913. Hepburn (D.)—A new osteometric board. *J. Anat. & Physiol.*, 1899, XXXIV, 111. Matthews (W.)—An apparatus for determining the angle of torsion of the humerus. J. Anat. & Physiol., 1887, XXI, 536–8. Russell (F.)—A new instrument for measuring torsion. *Am. Nat.*, 1901, XXV, 299.

[2] For original reports on this subject see Hrdlička (Aleš)—Study of the normal tibia. *Am. Anthrop.* 1898, XI, 307–312; *Proc. Ass. Am. Anat.*, 11 Sess., Wash. 1899, 61–66.—A further contribution to the study of the tibia, relative to its shapes. *Proc. Ass. Am. Anat.*, XII & XIII Ses. Wash. 1900, 12–13.—Typical forms of shaft of long bones. *Proc. Ass. Am. Anat.*, XIV Sess., Wash. 1901, 55–60. Also Bull. 62, Bur. Am. Ethnol., Wash. 1916. Consult also: Manouvrier (L.)—La platycnémie

Long Bones: The form of the shaft of the long bones is best differentiated at or near the middle of the bones, in adult individuals.

Variation in these shapes is greatest in the Whites. There are considerable racial and other group differences in the relative frequency of the different types of the shaft of the various bones; no one type, however, occurs exclusively or is completely absent in any of the human groups now existing. Some of the shapes are common to the anthropoid apes, and others occur far back in the animal kingdom.

The bones of the lower extremity show more numerous and better defined differentiations of form than those of the upper extremity. Of the individual long bones, the fibula presents the greatest variety of shapes; then follow in the order named, the tibia, femur, humerus, ulna, and radius.

Perfect representations of the various types of each bone are found whenever large collections are examined, but the less perfect and less clearly distinguishable types are always more common. Besides there is always a considerable percentage of bones which present intermediary or indefinite, and a small proportion which show combined forms.

The form of shaft common to all the long bones in man is the prismatic (No. 1). The outline of the cross-section of a shaft of this type approaches the equilateral triangle. This type is also common in apes, and more or less modified in lower mammals. The base of the prism is formed in the tibia, fibula, and humerus by the posterior surface; in the femur by the anterior surface; in the ulna by the internal, and in the radius by the external surface of the bone. In whites this type of shaft is most frequent in the humerus and tibia. In the fibula it is more or less modified by the narrow anterior surface of the bone.

The nearest modifications of type 1 are types of shaft Nos. 2 and 4. Type 2 occurs principally in the tibia, fibula and humerus, and is characterized by the obliquity of the posterior surface of the bone. The outline of the cross-section is a lateral triangle, a half lozenge (more or less). Type 4 occurs in all the long bones, and is charac-

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chez l'homme et chez les singes. *Bull. Soc. d'Anthrop.* Paris, 1887, Sér. 3, X, 128.—Mémoire sur la platycnémie chez l'homme et chez les anthropoids. *Mém. & Bull. Soc. d'Anthrop.* Paris, 1888, Sér. 2, III, 469.—Étude sur les variations morphologiques du corps de fémur dans l'espece humaine. *Bull. Soc. d'Anthrop.* Paris, 1893, Sér. 4, IV, 111; *Rev. d'École d'Anthrop.* Paris, 1893, III, 389. And Graves (Wm. W.)—The scaphoid scapula. Med. Record, May 21, 1910; *Wien. klin. Woch.*, 1912, XXV, No. 6; *J. Cutan. Dis.*, etc., April, 1913; and others on same subject.

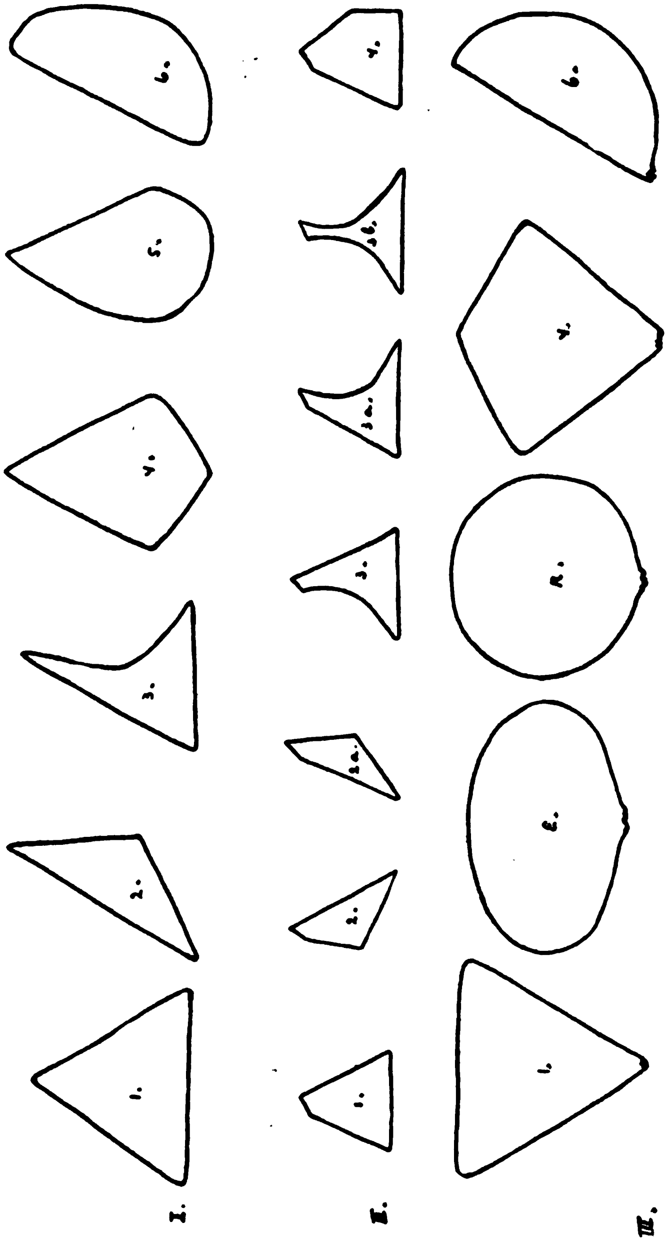

FIG. 19. Typical shapes of long bones of lower extremity, in cross-cut at middle. Upper row—Tibia; middle row—Fibula; lower row—Femur.

terized by the presence of a distinct additional surface on the shaft. The formation of the surface differs in the various bones. In the tibia the additional surface results from a division into two, by a vertical ridge, of the posterior surface; in the femur it is the anterior, in the radius the external, and in the ulna the posterior surface, which occasionally, through the influence of a vertical ridge, shows a formation of a distinct additional plane; in the humerus, finally, a new, anterior surface results occasionally by the broadening out of the anterior border of the bone. The cross section of the shaft in these cases differs from lozenge shape (more or less) to a more even quadrangle.

A special class of modifications of the form of the shaft is that where one or more surfaces of the bone show a pronounced concavity. We find such types (3, 3a, 3b,) particularly in the fibula, but also in the tibia, ulna and radius. In the fibula the concavity affects especially the external, but also the internal, and occasionally both the external and internal, and even the posterior surfaces; in tibia the character is observed on the external, and in the ulna and radius mainly on the anterior, flexor, surface.

Types 5, 6, *e* and *r*, are widely differing forms of the shaft of some of the long bones; all these types have, nevertheless, two features in common, and that is an indistinctness or complete absence of one or more of the borders of the bone, with marked convexity of two or all the surfaces.

Type 5 occurs occasionally in the tibia and frequently in the radius. It is marked by the convexity of the posterior tibial and external radial surface, and by indistinctness of the internal and sometimes also the external border in the tibia and the anterior and posterior borders in the radius. In both bones, but particularly in the tibia, this type of form represents a deficiency in the differentiation of the bone.

Type No. 6 occurs in the tibia, femur and humerus. The shaft is plano-convex. Types *e* (elliptical) and *r* (round, cylindrical) are found in the femur.

The condition of flatness in long bones occurs quite independently of the shape otherwise of these shafts. Flatness is not only found in the tibia, but also in the fibula (lateral), in the femur (antero-posterior of whole shaft, and, independently, antero-posterior of the upper part of the shaft, below the minor trochanter), and in the humerus (lateral). The flat femur (whole shaft) occurs almost exclusively in whites and independently of the flatness of other long bones. It is a

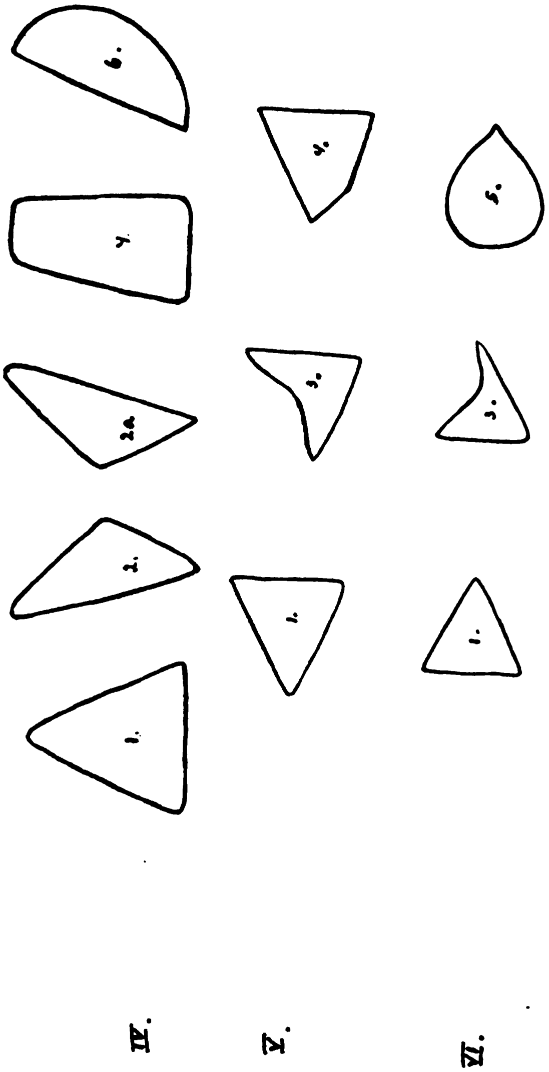

Fig. 20. Typical shapes of long bones of upper extremity, in cross-cut at middle. Upper row—Humerus; middle row—Ulna; lower row—Radius.

rare and possibly abnormal condition. A flat tibia is often accompanied by a flat fibula, and not seldom also by a platymeric (flat in upper part) femur.

The *scapula* presents three main shapes or types, namely, the triangular or wedge-shaped; the bi-concave, with its axillary and especially vertebral border concave (the "scaphoid" scapula of Graves); and the convex, with its vertebral border markedly convex.

Causes.—The shape of the bones is influenced by heredity, stage of development, sex, muscular activity, size of body, and pathological conditions.

Heredity: There are reasons to believe that certain types of bones run in families; and essentially through differences in heredity there are marked differences in the relative frequency of occurrence of the various types in different races.

Stage of life: During fetal life and early childhood, the shapes of bones are fewer in number, and do not always correspond to the shapes the bones will eventually have in the adult. Differentiation advances with age and the shape of a bone is probably not fully stabilized, particularly as to fluting, before advanced adult life.

Sex: Male bones show on the whole a greater differentiation of shapes than those of the females; also, some types of form are more common in one sex than in the other. Most, if not all these differences, may, however, be due to differences in muscular activities.

Race: The modern cultured Whites show more variation in shape of bones than the Indians, and the Indians more than the Negro or Negrito. The causes appear to be partly hereditary and partly occupational.

Muscular activity: Muscular peculiarities and muscular activites of the individual exercise a potent influence in modifying the shape of the bones.

Size of the body: The largest and the smallest bones of any variety show in general less differentiation than the average; and weak bones show more uniformity than the strongly developed.

Pathological: Very prolonged undernourishment or vitiated state of blood during fetal life or childhood may undoubtedly affect the general development as well as the shape differentiation of bones; but no proof exists that special pathological states are responsible for any special form-types of individual bones.

The sum of the observations points to the fact that the principal causes of the various shapes of the shafts of the long and bodies of other bones must be sought for, first, in original differences in the attachment of the various muscles to the shafts; and second, in an unequal development and work of the individual muscles during childhood and adolescence. The original differences in attachment, some of which can be clearly seen on the bones, are in all probability partly hereditary, partly early acquired conditions. The manner in which the differently attached or differently developed muscles affect the shape of bone must of course be largely if not entirely mechanical.

ADDITIONAL OBSERVATIONS

In addition to shapè, the bones of the skeleton offer an array of highly interesting points for observation, and many of these, as already mentioned, are of phylogenetic importance. Of these, the main ones will be included in the blanks to be given.

MEASUREMENTS

Blank: **Humerus**

Tribe............ Locality............ Observer............

Right Left

				At Middle:			Observations:					
Cat. No.	Sex	Age	Length Max.	Diam. Major (*a*)	Diam. Minor (b)	Index $\left(\frac{b \times 100}{a}\right)$	Shape of Shaft[1]	Perforation of Septum[2]	Supra-condylar Process[3]	Special	Pathological	

[1] Type *1* = prismatic; *2*, *2a* = lateral prismatic (*2* = posterior surface facing backward and inward; *2a* = posterior surface facing backward and outward); *4* = quadrilateral (anterior border broadened out to a distinct fourth surface); *6* = plano-convex; *i* = intermediary or indistinct.

[2] *pp* = pin point; *sm* = small; *m* = medium; *l* = large. When double or multiple, state so.

[3] None (—); rough trace = *r. tr.*; ridge: slight, medium, pronounced (*r. sl-m-pr*); tubercle: slight, or medium (*tb. sl-m*); process: 1/3, 1/2, 2/3, etc., complete (*pr.* 1/3, 1/2, 2/3, etc.).

Notes.—The *length* is taken on the osteometric board. Apply head to the vertical, take hold of bone by left hand, apply block to distal extremity, and raising bone slightly, move up and down as well as from side to side until maximum length is determined.

Diameter major at middle.—C. g. Determine mid-point of shaft on osteometric board and mark with pencil Lay rod of compass to the antero-lateral surface and apply branches to the bone.

Diameter minor at middle.—Apply fixed branch of sliding compass to the antero-lateral surface at middle and take measurement.

RADIUS

Tribe............ Locality............ Observer............

Right Left

Cat. No.	Sex	Age	Length Max.	Shape[1]	Anomalies	Pathological	Radio—Humeral Index[2]	

Note: Maximum length is taken in same way as that of the humerus.

ULNA

Tribe............ Locality............ Observer............

Right Left

Cat. No.	Sex	Age	Length Max.	Shape[3]	Anomalies	Pathological	

Note: Maximum length is taken in same way as that of the humerus.

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[1] *1* = prismatic; *2* = flexor surface concave (fluted); *5* = external surface convex, borders indistinct.

[2] $\frac{\text{Length of Radius} \times 100}{\text{Length of Humerus}}$.

[3] *1* = prismatic, *2* = flexor surface concave (fluted); *4* = quadrilateral (posterior) surface divided into two, so that the shaft presents four distinct surfaces, borders and angles.

Femur

Tribe............ Locality............ Observer............

Right

Cat. No.	Sex	Age	Length Bicondylar	Length Max.	Humero-femoral Index[1]	At Middle:		
						Diam. Antero-Posterior Maxim.	Diam. Lateral	Index[2]

(*Continued*) Left

At Upper Flattening:			Observations:					
Diam. Lateral Maxim.	Diam. Antero-posterior Minim.	Index[3]	Shape of Shaft[4]	Third Condyle[5]	Linea Aspera[6]	Anomalies	Patho-logical	

Notes: The *bicondylar length* of the femur is taken by adjusting both condyles to the vertical part of the osteometric board and, with the bone reposing on the board, applying the block to the other extremity.

The *length maximum* of the femur is measured in the same way as the maximum length of other bones (see under Humerus).

The *antero-posterior diameter at middle* (middle of shaft determined and marked beforehand) is the diameter maximum.

The *lateral diameter at middle* is taken so that the linea-aspera reposes on the stem of the sliding compass midway between the two branches of the same when these are applied to the bone.

[1] $\frac{\text{Length of Humerus} \times 100}{\text{Bicondylar length of femur}}$

[2] $\frac{\text{Diam. lat.} \times 100}{\text{Diam. ant.-post.}}$

[3] $\frac{\text{Diam. minimum} \times 100}{\text{Diam. maxim.}}$

[4] Type *1* = prismatic; *4* = quadrilateral (anterior surface divided by a vertical ridge in two); *r* = cylindrical (juvenile); *e* = elliptical; *pc* = plano-convex.

[5] *r* = ridge; *o. t.* = oblong tuberosity; *r. t.* = round tuberosity; *d* = depression; all: slight, moderate, or pronounced.

[6] sl., mod., pron.

In plano-convex and related femora the shaft is so deformed and the linea-aspera so displaced, that the measurement of the diameters is impractical and should be omitted.

Circumference of the shaft at middle as taken by some observers and contrasted with the length of the bone, gives data of some value for sexual identification; but the same may be done with the mean of the two diameters.

TIBIA

Tribe............ Locality............ Observer............

Right

Cat. No.	Sex	Age	Length (Less Spine) (*T*)	Length Maxim.	Tibio-femoral Index[1]	At Middle:		
						Diam. Antero-posterior Max. (*a*)	Diam. Lateral (*b*)	Index $\left(\frac{b\times100}{a}\right)$

(*Continued*) Left

Observations:					
Shape[2]	Peculiarities	Pathological Curvature	Exostoses	Other	

Notes: To take the ordinary length of the tibia introduce the spine into the orifice provided for this purpose in the vertical part of the osteometric board, apply outer parts of the condyles to the vertical outside of the orifice, let body of the bone repose on the horizontal part of the board, and apply block to the most distant point (malleolus).

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[1] $\frac{T \times 100}{\text{Bicond. } l. \text{ of femur}}$

[2] Type *1* = prismatic; *2* = lateral prismatic; *3* = external surface concave (fluted); *4* = posterior surface divided in two; *5* = posterior surface convex, internal border indistinct; *6* = plano-convex (gorilloid).

It is also useful to take the maximum length of the tibia. This is secured by placing the spine within the orifice as with the previous measurement, applying the most prominent point of the condyles to the vertical, taking hold of the body by the left hand and moving the bone from side to side as well as slightly upward and downward, while holding the block applied to the malleolus, until the maximum length is determined.

FIBULA

Tribe........... Locality............ Observer............

Right Left

Cat. No.	Sex	Age	Length Max.	Shape[1]	Anomalies	Pathological	

SCAPULA

Tribe............ Locality............ Observer............

Right

Cat. No.	Sex	Age	Height Total (*a*)	Height Infra-spinous (*b*)	Height Glenoid pt.-Infer. Angle (*x*)	Breadth (*c*)	Glenoid pt. Breadth *y*	Index: Total[2]	Index: Inferior[3]	Index (Hrdlička):[4]	Type[5]

Notes: The total height of the scapula is obtained by measuring in a straight line the distance from the superior to the inferior angle.

[1] *1* = Ordinary quadrilateral, approaching prismatic; anterior surface nearly absent to moderate; posterior surface facing directly backward or nearly so. *2* = Lateral prismatic; posterior surface facing backward and inward; medial surface much less in area than lateral; anterior surface narrow to broad. *2a* = relation between medial and lateral surface reversed, the latter being the narrower. *3* = medial surface fluted; *4* = lateral surface differentiated into two surfaces; *5* = lateral surface fluted; *6* = both medial and lateral surfaces fluted; *9* = all three surfaces fluted.

[2] $\frac{c \times 100}{a}$ [3] $\frac{c \times 100}{b}$ [4] $\frac{y \times 100}{x}$

[5] Type: *1* = triangular; *3* = biconcave ("scaphoid"), axillary and vertebral borders concave; *6* = convex, vertebral border convex.

SCAPULA

(*Continued*) Left

Observations:						
Shape of Superior Border[1]	Notch[2]	Vertebral Border[3]	Axillary Border[4]	Anomalies	Pathological	

The *infra-spinous height* is the height from the inferior angle to a point at which the spine transects the vertebral border of the bone. To determine this point hold scapula in left hand with dorsal surface up in such a way that the eye can follow the prolongation of the spine to the axillary border. Mark the mid point of the juncture of the spine with the border (and not the lower or upper limit).

The *glenoid point* height is the distance from the inferior angle to the center of the little roughness or fossa situated near the middle of the glenoid cavity.

The *breadth* of the scapula (*c*) is the diameter from the middle of the outer (dorsal) border of the glenoid cavity to the point where the spine intersects the vertebral border. (Broca, P. —Sur les indices de longueur de l'omoplate chez l'homme, les singes et dans la série des mammifères. *Bull. Soc. d'Anthrop.*, 1878, Sér. 3, I, 66.) The *glenoid point* breadth is that from this point.[5]

STERNUM[6]

Tribe............ Locality............ Observer............

Cat. No	Sex	Age	Total Length (Less Xiphoid) (s)	Length of Manubrium (m)	Manubrial Index $\left(\frac{m \times 100}{s}\right)$	Greatest Breadth of Body (b)	Sternal Index $\left(\frac{b \times 100}{s}\right)$	Maximum Thickness of Body	Number of Rib Facets		Anomalies	Remarks
									r.	*l.*		

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[1] *1* = horizontal, at right angle, or near, with coracoid; *2* = moderate obliquity upwards, angle 55–80; *3* = pronounced obliquity, angle near 45; *4* = semiquadrate; *5* = semicircular; *6* = wavy.

[2] *1* = none; *2* = slight; *3* = moderate; *4* = nearly a foramen; *5* = foramen.

[3] *1* = straight; *2* = concave; *3* = convex: slightly—moderately—pronouncedly.

[4] *1* = straight; *2* = teres process slight; *3* = moderate; *4* = pronounced.

[5] The glenoid point is a less variable landmark than the glenoid border; also it is the more suitable in measurements of scapulæ of various animals. The $y - x$ index is the most stable index of the scapula.

[6] Consult: Anthony (R.)—Notes sur la morphogenie du Sternum chez mammifères.

Notes: The *length of the sternum* as well as that of the *manubrium* is best measured on the osteometric board; the breadth and thickness of the bone are measured with the sliding compass. The thickness of the body should be measured between the facets for the ribs.

Among the anomalies are to be observed especially the foramen or defect in the lower part of the bone, and the occurence of episternals.

The relative proportions of the manubrium and body of the sternum show sexual as well as group differences; and the same may be said in regard to the fusion of the manubrium with the body of the bone.

CLAVICLES[1]

Tribe............ Locality............ Observer............

Right Left

Cat. No.	Sex	Age	Length Maximum	Conoid Tuberosity	Strength[2]	Curvature[3]	Anomalies	

Notes: The *length of the clavicle* is best determined on the osteometric board, but may also be measured by the small or the large sliding compass.

The comparison of the length of the clavicle with the length of the humerus (*claviculo-humeral index*) is useful as an indication of the relative development of the thorax.

The acromial extremity may in rare cases be separated; a few other anomalies may also occur.

Bull. Soc. d'Anthrop. Paris, 1901, II, 19–43. Dwight (Thos.)—The Sternum as an index of sex, height and age. *J. Anat. & Physiol.*, 1890, XXIV, 527–535. Krause (W.)—Ueber das weibliche Sternum. *Intern. Monatsschr. f. Anat. & Physiol.*, 1897, XIV, 21–32. Parker (W. J.)—Structure and development of the Shoulder Girdle and Sternum in the Vertebrates. *Roy. Soc. Publ.*, Lond., 1868. Paterson (A. M.)—The human sternum. Liverpool, 1904; also *Brit. Med. J.*, 1902, II; and *J. Anat. & Physiol.*, 1900, XXXV, Pt. 1.

[1] Consult Pasteau (E.)—Recherches sur les proportions de la Clavicule. *Thèse méd.*, Paris, 1879; also Parsons (F. G.)—On the proportions and characteristics of the modern English Claricle. *J. Anat., Lond.*, 1916, LI, 71–93.

[2] *Sl* = slender; *m* = medium; *str* = strong; *mas* = massive.

[3] *Sl* = slight; *m* = medium; *pron* = pronounced.

RIBS[1]

Tribe............ Locality............ Observer...........

Cat. No.	Sex	Age	Number Present		Anomalies	Fractures and Pathological	1st Rib Shape.[2]	Remarks
			R.	L.				

Notes: In skeletal material obtained from older graves the ribs are seldom all present and in good condition; nevertheless their examination should not be neglected. Cervical, supernumerary, bifid, bicipital and fused ribs are of special interest; and other anomalies may occur.

The first rib deserves special attention, particularly as to its shape. The development of the scalene tubercle may also be noted on the first rib.

SPINE[3]

Tribe............ Locality............ Observer............

			Atlas:		Other Cervical:			Dorsal:			Lumbar:		
Cat. No.	Sex.	Age	Anomalies	Remarks	Number	Anomalies	Remarks	Number	Anomalies	Remarks	Number	Anomalies	Remarks

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[1] Bardeen (Ch. R.)—Costo-vertebral variation in Man. *Anat. Anz.*, 1900, XVIII, 377–382. Hrdlička (Aleš)—Contribution to the Osteology of Ribs, *Proc. Ass. Am. Anat.*, XIV Sess., Wash., 1901, 61–68. Tredgold (A. F.)—Variations of Ribs in the Primates with especial reference to the number of sternal Ribs in Man. *J. Anat. & Physiol.*, 1897, XXXI, 288–302.

[2] *1* = curved (semilunar); *2* = monoangular or pistol-shaped (nearly straight neck, with nearly straight body); *3* = biangular (distinct angle in body, besides that between neck and body).

[3] Consult: Anderson (R. J.)—Observations on the diameters of human vertebrae in different regions. *J. Anat. & Physiol.*, London, 1883, XVII, 341–4. Bardeen (Chas. R.)—Numerical Vertebral Variation in the Human Adult and Embryo; *Anat. Anz.*, 1904, XXV, 497–519. Cunningham (D. J.)—Lumbar Curve in Man and the Apes. Dublin, 1886. Dubreuil-Chambardel (L.)—Variations sexuelles de l'Atlas. *Bull. & Mém. d'Anthrop.*, Paris, 1907, VIII, 399–404. Dwight (Thomas)—

Notes: Various measurements and many detailed observations are possible on the spine and its different constituents. As to measurements, the most interesting are the relative lengths of the cervical, dorsal and lumbar parts of the spine compared with the total length of the three. The length of these parts is best taken by the small and large sliding compasses, between the mid points anteriorly of the upper and lower border of the body of the first and last vertebra of each segment, with the bones held in a close and natural apposition.

The atlas should receive special attention, for it is subject to many independent variations, particularly in respect to blood vessel foramina and canals.

The lowest part of the dorsal and the uppermost as well as lowermost parts of the lumbar segment, are also of special interest, the former on account of occasional numerical variation, the latter on account of occasional separation of neural arch, a presence of a sacral element with more or less assimilation, etc.

The minor anomalies of the spine and its constituents should be reserved for special study.

SACRUM, PELVIC BONES, PELVIS

Tribe............ Locality............ Observer............

Cat. No.	Sex	Age	Sacrum:						
			Height Maxim.[1]	Breadth Maxim.	Sacral Index[2]	Number of Segments	Curvature[3]	Curvature Begins at[4]	Special

Description of the Human Spines showing numerical variation. Mem. Boston Soc. Nat. Hist., 1901, 237–312, also, *Anat. Anz.*, 1901, XIX, 332, 337–347; and *Anat. Anz.*, 1906, XXVIII, 33–40, 96–102. Hrdlička (Aleš)—The atlas of Monte Hermoso. In *Bull. 52, Bur. Am. Ethnol.*, Wash. 1912, 364–9. Papillault (G.)—Variations numériques des vertèbres lombaires chez l'homme. *Bull. Soc. d'Anthrop.*, Paris, 1898, IX, 198–222. Ranke (J.)—Zur Anthropologie der Halswirbelsäule. Sitz. math. phys. Cl. bayer. Akad. Wiss., 1895, XXV, 1–23. Ravenel (M.)—Die Maassverhältnisse der Wirbelsäule und des Rückenmarkes beim Menschen. *Inaug. Dissert.*, Leipzig, 1877, 1–27. Regalia (C. E.)—Sulla causa generale delle anomalie numeriche del rachide. *Arch. p. Antrop. & Etn.*, 1895, XXV, 149–219. Rosenberg (E.)—Ueber die Entwicklung der Wirbelsäule. *Gegenbaur's Morphol. Jahrb.*, Leipzig, 1875, I, 1–111. Soularue (G. Martial)—Étude des proportions de la colonne vertébrale chez l'homme et chez la femme. *Bull. Soc. d'Anthrop.* Paris, 1900, Sér. 5, I, 132–147. Zoja (G.)—Sulle varietà dell'atlante. *Bol. sci.*, 1881, Nos. 1 & 2, repr. 24 pp., Also C. R. R. Ist. Lomb., Cl. Sc. mat. & nat., 1881, XIV, 269–296.

SACRUM, PELVIC BONES, PELVIS

(*Continued*)

Ossa Innominata:						Pelvis:					
Height Maxim.		Breadth Maxim.		Mean Index[5]	Special Features	Breadth Maxim.[6]	Total Index[7]	Superior Strait: Breadth Maxim.	Diameter Antero-posterior Maxim.[8]	Pelvic Index	Remarks
Right	Left	Right	Left								

Notes: In measuring the height of the sacrum use sliding compass and apply points of instrument to middle of promontory and middle of anterior-inferior border of the fifth sacral vertebra. For general comparative purposes measure only sacra with five segments.

In measuring breadth apply stem of compass to the upper surface of the body of the first sacral vertebra and measure the greatest expanse of the lateral masses of the bone.

The height of the ossa innominata is best measured on the osteometric board. Apply ischium to the vertical part of the board, hold bone with left hand, apply block to iliac border with right hand and move bone up and down and from side to side until maximum measurement is obtained.

The breadth of the ossa innominata is best measured by the sliding compass. It is the distance between the anterior and posterior superior spines.

For measuring the pelvis as a whole articulate the bones, hold with both hands, invert, and secure breadth maximum of ilia on the osteo-

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[1] Long branch of sliding compass applied ventrally, in median line, to anterior border of lower end and to promontory.

[2] $\frac{\text{Breadth} \times 100}{\text{Height}}$.

[3] Slight, moderate, pronounced.

[4] Name segment (from above).

[5] $\frac{\text{Mean breadth} \times 100}{\text{Mean height}}$.

[6] Pelvis held together with bones in natural position; the breadth is the bi-iliac maximum, and can be taken handily on the osteometic board, or by a second person with the large sliding compass.

[7] $\frac{\text{Breadth} \times 100}{\text{Mean height of ossa innominata}}$.

[8] From promontory of the sacrum to the nearest point on the ventral border of the pubic bones.

metric board. With the help of a pelviphore (such as that of Emmons) the taking of this measurement and of those of the brim becomes a simple matter.

To measure the diameters of the superior strait or brim of the pelvis without a pelviphore, hold pelvis in left hand, and use small sliding compass. The antero-posterior diameter is that between the mid point on the promontory of the sacrum and the nearest point on the ventral borders of the pubic articulation. The lateral diameter is the maximum transverse diameter of the brim.

A natural slight separation of the pubic bones should be retained during all measurements.

SHORT BONES

Patella.[1]

Tribe............ Locality............ Observer............

Right Left

Cat. No.	Sex	Age	Height Maxim.	Breadth Maxim.	Thickness Maxim.	Breadth-Height Index $\frac{(B \times 100)}{H}$	Patellar Module $\frac{(H+B+T)}{3}$	Vastus Notch[2]	

Notes: All the measurements to be taken with the small sliding compass. In measuring the height and breadth of the bone, move the latter slightly from side to side between the branches of the compass until the maximum measurement is determined. The height is taken by applying the fixed branch to the anterior surface of the bone and bringing the movable branch posteriorly over its thickest parts.

The vastus notch shows interesting variations.

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[1] Consult: Corner (E. M.)—Varieties and structure of the Patella of Man. *J. Anat. & Physiol.*, 1900, XXXIV, XXVII–XXVIII; also Ten Kate (H.)—Rotule. *Rev. Mus. La Plata*, 1896, VII, 12–16. Also *Bull. 62, Bur. Amer. Ethnol.*, Wash. 1916.

[2] — none; *sl* = slight; *m* = moderate; *l* = large.

Calcaneus[1]

Tribe............ Locality............ Observer............

Right Left

Cat. No.	Sex	Age	Length Maxim.	Breadth Minim.	Height of Body	Breadth-Length Index $\frac{(B \times 100)}{L}$	Breadth-Height Index $\frac{(B \times 100)}{H}$	Height-Length Index $\frac{(H \times 100)}{L}$	Module $\frac{(L+B+H)}{3}$	Articular Facets for Astragalus	Anomalies	Remarks	

Notes: All measurements to be taken with the small sliding compass. The taking of the maximum length will be self-evident. To secure the breadth, the branches of the compass should be applied to the sides of the bone in the region of the minimum thickness of its body. The most practicable height of the calcaneus is obtained by moving the bone from side to side between the branches of the compass, which are applied to what is seen to be the greatest constriction of the body (approximately its middle).

As to visual observations on the Os calcis, the greatest interest attaches probably to the number and conformation of the articular facets for the astragalus. These facets may be two in number, anterior and posterior. But the anterior facet may be divided into two by a ridge; or it may be replaced by two facets, anterior and median, completely separated by a narrow to moderately broad groove or space; or, finally, in place of the single oblong anterior facet there may be a small to rudimentary anterior and a medium-sized median facet, separated by a broad and deep notch.

An additional point of some interest is the development of the peroneal spine.

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[1] See *Bull. 62, Bur. Amer. Ethnol.*, Wash., 1916.

ASTRAGALUS[1]

Tribe............ Locality............ Observer............

Right Left

Cat. No.	Sex	Age	Length Maxim.	Breadth Maxim.	Height Maxim.	Breadth-Length Index $\frac{(B \times 100)}{L}$	Height-Length Index $\frac{(H \times 100)}{L}$	Module $\frac{(L+B+H)}{3}$	Facets for Calcaneus[2]	Special	

Notes: For length maximum, apply stem of sliding compass to lowest (most prominent) parts of the medial surface on the bone.

The maximum breadth is taken by applying the fixed branch of the sliding compass to the lowest (most prominent) parts on the medial surface of the bone.

The maximum height of the astragalus is best taken on the osteometric plane, on which the bone is placed so that all the three lowest points of its inferior surface touch the vertical part, while the block is applied to the most prominent part of the bone from the opposite direction.

A comparative study of the calcaneus facets on the talus with the corresponding facets on the latter bone, is of considerable interest, and shows some racial variations.

SCAPHOID[3]

Tribe............ Locality............ Observer............

Right Left

Cat. No.	Sex	Age	Breadth Maxim.	Height Maxim.	Stoutness Maxim.	Height-Breadth Index $\frac{(H \times 100)}{B}$	Stoutness-Breadth Index $\frac{(S \times 100)}{B}$	Facet for Cuboid[4]	Facet for Talus, Form[5]	Tuberosity[6]	Additional	

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[1] See *Bull. 62*, *Bur. Am. Ethnol.*, Wash., 1916.

[2] *1* = one facet not divided by any ridge; *2* = one facet divided into two by a ridge; *3* = two distinct facets, but slightly connected or completely apart.

[3] See *Bull. 62*, *Bur. Am. Ethnol.*, Wash., 1916.

[4] Present or absent.

[5] *pf* = pyriform; *q* = quadrilateral; *i* = intermediary or indefinite.

[6] *p* = pointed; *bl* = blunt (markedly); *sq* = squarish.

Notes: The maximum breadth of the bone is taken by the small sliding compass and is measured from the extremity of the tuberosity ad maximum.

To take the maximum height of the bone use the large sliding compass with broad branches; hold instrument vertically, lay bone on movable branch on its talus facet, raise the branch until the bone touches the under surface of the fixed branch and read measurement.

To measure the stoutness use same instrument as for height. Lay bone on the movable branch of the compass on its dorsal or superior surface, let it assume a natural position, and raise the branch until the most prominent part of the plantar surface of the bone touches the under surface of the fixed branch.

CUBOID[1]

Tribe............ Locality............ Observer............

Right Left

Cat. No.	Sex	Age	Length Maxim.	Breadth Maxim.	Thickness Maxim.	Breadth-Length Index $\frac{(B\times100)}{L}$	Thickness-Length Index $\frac{(T\times100)}{L}$	Module $\frac{(L+B+T)}{3}$	Facet for Cuneiform[2]	Facet for Talus[3]	Additional	

Notes: The maximum length of the bone is measured with the small sliding compass, between the most prominent point on the superior and inferior borders of the distal or metatarsal facet of the bone and the point at the inferior medial angle (calcanean process).

The maximum breadth is obtained with the cuboid resting on its medial surface in such a position as it naturally assumes. This and the next measurement are best taken by the large sliding compass with broad branches.

The maximum thickness is taken with the cuboid resting on its anterior surface in such position as it naturally assumes.

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[1] *See Bull. 62, Bur. Am. Ethnol.*, Wash., 1916.

[2] *s* = single; *r* = divided in two by a well marked ridge; *3* = double (connected or not).

[3] Present or absent.

Internal Cuneiform[1]

Tribe............ Locality............ Observer............

Right Left

Cat. No.	Sex	Age	Height Maxim.	Breadth Minim.	Breadth-Height Index $\frac{(B \times 100)}{H}$	Metatarsal Facet[2]	Additional	

Note: Measurements taken with sliding compass. Height maximum is secured by applying the fixed branch of the compass to the most prominent parts of the inferior surface of the bone and bringing the other branch into apposition.

The minimum breadth, in the middle of the bone, is obtained by applying the fixed branch of the compass so that it rests on both lips of the scaphoid facet, and bringing the other branch into apposition with the bone. It is the only practicable breadth in all specimens.

External cuneiform: Note frequency of absence of facet for fourth metatarsal, also for second metatarsal.

Middle Cuneiform: Note character of central ligamentous depression and canal running downward from this.

Bones of the Hand[3]

Tribe............ Locality............ Observer............

Right Left

			Bones of Carpus:		Metacarpals:				Phalanges:		
Cat. No.	Sex	Age	Number	Observations	Number	Remarks	Length Max. of 1st Metacarpal	Metacarpo-Humeral Index[4]	Number	Remarks	

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[1] See *Bull. 62, Bur. Am. Ethnol.*, Wash., 1916.

[2] Single or double.

[3] See *Bull. 62, Bur. Am. Ethnol.*, Wash., 1916.

[4] $\frac{\text{Max. length of 1st metacarpal} \times 100}{\text{Max. length of humerus}}$.

Bones of the Foot[1]

Tribe............ Locality............ Observer............

Right ..Left

Cat. No.	Sex	Age	Metatarsals:					Re-marks	Phalanges:		
			Number	Observations	1st Metatarsal:				Num-ber	Re-marks	
					Length Maxim.	Pollux-Hallux Index[2]	Hallux Femur Index[3]				

ESTIMATION OF STATURE FROM PARTS OF THE SKELETON[4]

The International Agreement of Geneva stipulates that: "For the reconstruction of the stature with the aid of the long bones, the maximum length shall be measured in all cases save in those of the femur which is to be measured in the oblique position, and the tibia which is also be to measured in the oblique position, the spine being excluded."

Under these conditions and until something more serviceable may be provided, the student is advised to use Manouvrier's tables, which are here reproduced. These tables apply only to bones of adults; and a proper sexual identification is in each case of the greatest importance. All the long bones present should be measured and the mean length of each pair used for the approximations in the table, the mean of the total of approximations giving the stature.

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[1] See *Bull. 62, Bur, Am. Ethnol.*, Wash. 1916.

[2] $\frac{\text{Max. length of 1st metacarpal} \times 100}{\text{Max. length of 1st metatarsal}}.$

[3] $\frac{\text{Max. length of 1st metarsal} \times 100}{\text{Bicondylar length of femur}}.$

[4] Dwight (Thos.)—Methods of estimating the height from parts of the skeleton. *Med. Rec.*, Sept. 8, 1894. (Gives data for estimating stature also from length of sternum and that of the spine.) Manouvrier (L.)—Détermination de la taille d'après les os longs. *Rév. Éc. d'Anthrop.* Paris, 1892, II, 227.—La détermination de la taille d'après les grands os des membres. *Mem. Soc. d'Anthrop.*, Paris, 1893, Sér. 2, IV, 347–411. Pearson (K.)—On the reconstruction of the stature of prehistoric races. *Philos. Trans. R. Soc.*, London, 1899 (Mathematical); CXCII, Ser. A, 169–244. Rollet (E.)—La mensuration des os longs des membres. *Thèse méd.*, Lyon, 1899 (Similar to Manouvrier). Topinard (P.)—De la restitution de la taille par les os longs. *Rev. d'Anthrop.*, Paris, 1885, VIII, 134.—Procédé des mensuration des os longs dans le but de réconstituer la taille. *Bull. Soc. d'Anthrop.* Paris, 1885, VIII, 73–83. Also *Éléments d'Anthropologie générale* (used maximum lengths throughout). Older data unreliable and lack precision of methods.

The final estimate will be the more reliable the larger the series of subjects involved. In single individuals the error, as Dwight has shown, may be very considerable, particularly in tall males (up to11.9 cm.).

The author obtained the following correspondences between the humerus and stature in 354 male and 82 female dissecting room individuals, Whites, 22–25 years of age, and where both humeri could be measured.

Mean Length of Humerus, in Percentage of Stature: $\frac{H \times 100}{S}$								
	17.7	18.1 to 18.5	18.6 to 19	19.1 to 19.5	19.6 to 20	20.1 to 20.5	20.6 to 21	21.1 to 21.6
Percent of Bones								
Males........	1.4	11.7	24.3	27.1	21.6	9	3.7	1.1
Females......	...	12.2	20.7	31.7	18.3	9.8	7.3	...

MANOUVRIER'S TABLES SHOWING THE CORRESPONDENCE OF BONE LENGTHS AMONG THEMSELVES AND WITH STATURE

Males						
Humerus	Radius	Ulna	Stature	Femur	Tibia	Fibula
cm.	cm.	cm.	cm.	cm.	cm.	cm.
295	213	227	1,530	392	319	318
298	216	231	1,552	398	324	323
302	219	235	1,571	404	330	328
306	222	239	1,590	410	335	333
309	225	243	1,605	416	340	338
313	229	246	1,625	422	346	344
316	232	249	1,634	428	351	349
320	236	253	1,644	434	357	353
324	239	257	1,654	440	362	358
328	243	260	1,666	446	368	363
332	246	263	1,677	453	373	368
336	249	266	1,686	460	378	373
340	252	270	1,697	467	383	378
344	255	273	1,716	475	389	383
348	258	276	1,730	482	394	388
352	261	280	1,754	490	400	393
356	264	283	1,767	497	405	398
360	267	287	1,785	504	410	403
364	270	290	1,812	512	415	408
368	273	293	1,830	519	420	413
Mean Coefficients for bones shorter than those shown in the Table:						
5.25	7.11	6.66	.....	3.92	4.80	4.82
Mean Coefficients for bones longer than those shown in the Table:						
4.93	6.70	6.26	.....	3.53	4.32	4.37

To determine from this table the stature of the living, add 2 mm. to each length; take the mean of the resulting statures, and subtract 2 mm. from the final height thus obtained.[1]

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[1] Dwight found that a large proportion of the errors with the Manouvrier tables was due to this subtraction, and advocates that this recommendation be not followed. It should be stated by the worker whether or not it was followed.

MANOUVRIER'S TABLES SHOWING THE CORRESPONDENCE OF BONE LENGTHS AMONG THEMSELVES AND WITH STATURE—*Continued*

Females						
Humerus	**Radius**	**Ulna**	**Stature**	**Femur**	**Tibia**	**Fibula**
cm.	cm.	cm.	cm.	cm.	cm.	cm.
263	193	203	1,400	363	284	283
266	195	206	1,420	368	289	288
270	197	209	1,440	373	294	293
273	199	212	1,455	378	299	298
276	201	215	1,470	383	304	303
279	203	217	1,488	388	309	307
282	205	219	1,497	393	314	311
285	207	222	1,513	398	319	316
289	209	225	1,528	403	324	320
292	211	228	1,543	408	329	325
297	214	231	1,556	415	334	330
302	218	235	1,568	422	340	336
307	222	239	1,582	429	346	341
313	226	243	1,595	436	352	346
318	230	247	1,612	443	358	351
324	234	251	1,630	450	364	356
329	238	254	1,650	457	370	361
334	242	258	1,670	464	376	366
339	246	261	1,692	471	382	371
344	250	264	1,715	478	388	376
Mean Coefficients for bones shorter than those shown in the Table:						
5.41	7.44	7.00	.....	3.87	4.85	4.88
Mean Coefficients for bones longer than those shown in the Table:						
4.98	7.00	6.49	.....	3.58	4.42	4.52

ADDENDA

MEASUREMENTS OF TEETH

To express the proportionate size of the crowns of the premolars and molars to that of the skull in different races, Flower compared the distance from the front of the first premolar to the back of the last molar *in situ*, with the distance from the front of the foramen magnum to the naso-frontal suture (basi-nasal length), in the form of a "dental index."—

$$\text{Thus: } \frac{\text{Length of teeth x 100}}{\text{Basi-nasal length}} = \text{Dental index,}$$

and by this means he has divided the various races into *microdont* (index 42 to 43, Europeans, Egyptians, etc.), *mesodont* (index 43 to 44, Chinese, American Indians, Negroes, etc.), and *macrodont* (index 44 and upwards, Australians, Melanesians, etc.).[1]

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[1] Flower (W. H.)—On the size of the teeth as a character of race. J. Anthrop. Inst. 1885, xiv, 183–187. See also Cunningham (D. J.)—Textbook of Anatomy, 3d ed., 1909, 1029.

Individual Teeth.—Valid measurements can be secured only on teeth that are normal and unworn (or worn only so that the dimensions we want to measure are not affected).

Incisors: Main measurements—The total length of the tooth, and the greatest breadth of the crown (at right angles to the long axis of the tooth). Additional measurements are the maximum antero-posterior diameter of the crown (at its base), the minimum breadth of the crown (also at its base), and the height of the crown (in median line on the labial surface).

Canines: Principal measurements—Total length, and height of crown (in median line, labial surface). A useful measurement is that of the total displacement of the tooth, in glycerine, oil or other liquid, in a graduated small jar or tube.

Premolars and molars: Essential measurements—Maximum height (with axis of the tooth vertical); length and breadth. The length and breadth measurements of these teeth are not as easy to make as might at first appear, which is particularly true of the anterior premolar in some of the lower forms of mammals. The most satisfactory rule is to measure the length along the median antero-posterior axis of the tooth as it lies or lay in the jaw; and the breadth at right angles to this axis.

The above measurements on individual teeth are of value both anthropologically and phylogenetically; but due to the care with which they must be taken and the time involved in getting the specimens, they should be reserved for special investigations.

The teeth of man, even more than any of his other structures, call for careful comparative work on Primates and lower mammals.

Measurements of Brain

Uniformity in brain measurements is equally as desirable as uniformity in the measurements of other parts of the body; but no attempt has yet been made at their international definition and regulation. Each author so far has followed his own inclinations, with the result that outside of weight but little comparison of the measurements is possible.

The brain is not an easy organ to measure. Due to its softness, from the moment it is exposed it tends to sag down more or less according to the condition of the body and the temperature, and it may readily be deformed if not given the best of care in preservation. Yet measurements that could be used for comparison both within and beyond the human phylum are highly desirable, and every effort should be made in this direction by those favorably situated for such studies.

The most common and easiest of brain measurements is the *weight*. The brain is weighed without the *dura mater*, immediately after extraction. Should any excess of liquid be evident, allow 5 to 15 minutes for drainage. If the main component parts are to be weighed separately use care in severing.

As to other measurements of the organ, in 1901[1] the author proposed a sensible scheme which he regards as the simplest, the most promising and the only universally applicable system so far suggested. It relates essentially to the cerebrum, and consists of taking the maximum antero-posterior diameter of each hemisphere as a basis and a horizontal, to which all other measurements are referred as so many verticals. Under this system each part of the brain and each location may be readily expressed or shown in a percentage of the horizontal, which gives us valuable data for comparison. The choice of the points from which to draw the verticals depends on the object of the study, but the principal points will doubtless become standardized by use, as well as by future agreements.

The method of procedure is simple. The appliance needed is a frame, the lower part of which consists of an adjustable platform for the cerebrum or a hemisphere, while the upper part resembles the rod of the sliding compass. It is graduated, and along it slides a needle which may be lowered or elevated as required. The observer ascertains with due care the frontal and the occipital poles, adjusts the platform of his frame so that the line connecting these points is horizontal, brings the frontal pole lightly into contact with the vertical part of the frame on the left (his zero), sees to it that the axis of the brain or hemisphere is parallel to the graduated rod above, marks on the hemisphere or hemispheres the points to which he wishes to measure and proceeds with the measurements. The upper part of the frame holding the needle is movable backwards and forwards so as to permit the bringing of the needle vertically over the different points from which the measurements are to be taken.

In the above way each measurement is like a section of the hemisphere and hence of its basic horizontal, and can readily be contrasted with the whole. We are comparing then antero-posterior segments of the brain, rather than simple linear dimensions.

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[1] An Eskimo Brain. *Am. Anthrop.*, N. S., III, 454–500; also 8° N. Y., 50 pp.

The lateral and height measurements may, if desired be obtained similarly; and the length, breadth and height diameters may be supplemented by such surface arcs as may be deemed of importance.

The measurements may be taken on a fresh brain, but as there is always more or less sagging, it is preferable to take them on hardened specimens, in which the relative proportions of the parts will, if the specimen has not been deformed, remain the same as they were in the fresh brain.[1] The best specimens however for measurement are brains hardened *in situ* by near-freezing (temporary), or by 5 to 10 per cent formalin injections.

In all cases it is important to ascertain the endocranial maximum length (on each side), as well as the maximum breadth of the cranial cavity (lined by *dura*). These correspond to the measurements of the brain before extraction.

INTERNAL ORGANS

No system of measurements has as yet been devised for the internal organs.

The weight is ascertained as a rule, and should further measurements be desired they would naturally include where possible the greatest length, breadth and thickness, with the displacement (or capacity), of the organ.

The study of the internal organs is greatly hindered by pathological alterations, notwithstanding which it is of considerable anthropological importance.[2]

PLASTER CASTS

In demonstrations and museum exhibits, as well as in original investigations, an important part is played by good casts. An ideal collection in physical anthropology ought to include a representation in good facial and other casts of every important branch and group of humanity. As it is, there is no institution that possesses casts of the various racial divisions of even the Whites alone. Nor could there be made as yet in any institution with an anthropological section an exhibit of any one nation, illustrating physical and developmental types, and such groups as that of the most beautiful individuals, the greatest athletes, the most talented men and women in that nation. More has really been done in this respect on primitive peoples than on those more civilized; but there is everywhere an opportunity for much further endeavor.

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[1] For hardening brains see Hrdlička (A.)—Brains and Brain Preservatives. *Proc. U. S. Nat. Mus.*, 1906, XXX, 245-320*b*, 27 fig.

[2] Compare Bean (R. B.)—*Am. J. Phys. Anthrop.*, 1919, II.

If an opportunity to make casts is limited, choose only adults of middle age; otherwise extend the work to all age groups. Very interesting series also are afforded by whole families.

Casts are made from plaster of paris. Efficiency in making casts is best acquired under an instructor. The process of making a facial cast, given here for those who may have a chance to practice it, is as follows:

Have the subject seated comfortably on a chair. See that the face preserves its most natural expression, the eyes being open, and warn the subject against moving, swallowing, coughing, sneezing or spitting. The features and lips should not be tight or puckered or the mouth distorted; endeavor to have the subject think of something peaceful, agreeable. Fasten a wide, ample piece of cloth on the neck of the subject; it should be long enough to cover his feet to prevent soiling by plaster. Brush hair backward without pulling the skin and fasten by moderately tightly applied band about 2½ inches broad, leaving but little hair exposed over the forehead and temples. Work into this exposed hair, and also into the eyebrows mustache and beard, enough soap paste to prevent inclusion into plaster. Use commercial green soap, or boil ordinary soap with water until the liquid thickens. Introduce a little cotton into each ear. Oil lightly with camel hair brush whole face and neck using light paraffin oil or any other non-viscid oil; also oil the hair band. Care must be exercised that no excess of the oil is left anywhere and that nothing enters the eye. This finishes the preparation. No nasal tubes.

The next step consists in mixing the plaster. Only the best dental or alabaster plaster should be used. Fill small basin with luke-warm or at least not too cold water, and add a pinch of common salt for quicker setting (if needed). Sift plaster on top of water by hand, without mixing, until moment when plaster stops sinking—the exact stage is learned from practice. Mix then without churning, with common spoon gather surface bubbles and dirt, and the liquid of cream consistency is ready for use.

The first layers of plaster are applied to the forehead, about the eyes and over the upper part of the face with the help of a little spoon or a spatula. The excess of the plaster flows down over the face and on to the apron, or the plaster basin which is held underneath.

The upper part of the face being covered, advance to ears and lower part of face. Fill one ear only, but carry plaster around far enough to show fully location of other ear. If plaster begins to thicken, strengthen what is already on without employing the slightest pressure, and make or have made rapidly a new supply, slightly thicker than the first. Then with the help of spatula or spoon and still avoiding pressure cover whole face.

While cast is drying add gently more about eyelids, taking again care to use no pressure and especially not to get any plaster into subject's eye where it would cause burning. Add also, if necessary, more plaster about nostrils. On the ear that is covered carry plaster a little over convex border.

Strengthen cast over forehead and median line of face; thickness of cast should range from about one-eighth to one-quarter of an inch.

When through with application of plaster, post yourself behind subject and gently support his head until cast is sufficiently hard. During hardening plaster will generate warmth, but this never becomes too inconvenient or dangerous.

Proper hardness of cast is learned through experience; it can be ascertained by tapping it with a finger or some harder object.

Removal may begin before hardening is complete at the hair ribbon, which is slowly drawn backward. Then proceed all along the edge of the cast and press skin back from it. Free helix of covered ear and draw ear backward. All this can be begun quite early to occupy subject's attention and satisfy him and it may be carried on so slowly that the plaster has ample time to harden. To take cast off, lay left hand on its top, grasp with the right its chin part, manipulate slowly and carefully up and down, and push and pull downward and forward until it slips off.

There is occasionally some difficulty on account of the beard or very large malars; or the subject may have tried to swallow or cough or has moved so that a part of the cast is cracked or imperfect; or a portion of the cast may be broken off through haste or maladroitness in removing it. All that can be advised in such contingencies is patient manipulation, or careful repair by fitting the separated parts and adding plaster to the outside of cast.

The finished cast is allowed to dry thoroughly, after which it is ready for packing. Mark on surface with sharp point whatever data are essential to go with cast. Pack carefully and tightly.

In this manner, after due preliminary practice, from eight to ten first class facial casts can be made in a day. To take a cast of the whole head is difficult and has no advantage. With a good facial cast, photographs and measurements, the head can be modelled almost to perfection.

Casts of the body should never be undertaken except by one well practised in the art, for the operation is not without danger to the subject. Casts of the lower part of the trunk and the limbs need experienced hands. The skin must in all instances be well oiled and the part to be cast must not be deformed by wrong position or pressure. A provision for the removal of the cast in sections is a necessity and is usually done by including in the first layer of plaster, along the line of intended separation, a linen thread and by cutting the cast with this as it begins to harden. The preparation of the plaster and other details are practically the same as in facial casting.

In packing casts, pad well and tightly with very dry hay or other suitable substance, and use only smaller boxes or barrels. In especially important cases, and where the casts are to be transported a great distance, individual little boxes for each cast, a number of which is then packed in a larger case, are of great advantage.

ANTHROPOMETRIC INDICES.

Under the term 'index' in anthropometry is understood the percental relation of two measurements. It is habitual to use the smaller measurement as the dividend and the larger as the divisor, so that the index is usually less than 100.

The index is the simplest expression of the geometric relation of two dimensions and as such is of much utility for the prompt conveyance of a notion as to the shape or relative size of parts. The index in general is also more permanent than the absolute dimensions of the parts, and therefore more valuable for group comparisons.

Due to their usefulness and stability, the indices in anthropometry have almost from the beginning assumed a great favor as well as importance. For the same reasons also they have become greatly multiplied, and their value—particularly that of the cephalic index—has been sometimes overrated. No index, it is plain, can have more stability than the physiological and mechanical conditions that control the relation of the parts concerned; and as these conditions are not immutable, so the indices are subject to change.

As in a large majority of cases the correlation of measurements is self-evident, there is a general agreement among workers as to the constituents of the indices; but in the course of time there have developed considerable differences of opinion as to the grouping of the indices and in the nomenclature of the resulting divisions.

In the examination of any large group of people it will be found that each given index will show a rather extended range of variation. A certain part of this range will embrace the normal average, together with the normal oscillations of the index for the anthropologically purest part of that particular group; but as few larger ethnic groups to-day are free from admixture, it may safely be expected that a certain proportion of the indices obtained on the group will express aberrations. Such aberrations may be detected by a proper seriation and mapping out of the indices. But we are assisted in expressing them, as in expressing the differences in the indices of separate ethnic and even biologic groups, by definite subdivisions or classifications of the indices. That is why this subject has received so much attention.

But such classifications, to be of real value, should self-evidently be as little arbitrary as possible, and have the closest attainable relation to natural groupings.

These facts were well recognized from the start in anthropology, and earnest efforts were made to arrive at the most logical classifications. For guidance there were on the one hand the principal natural subdivisions or races of man, and on the other an augmenting and comprehensive supply of measurements. It could readily be seen that a classification of any index which would not harmonize with the distribution of the index in at least the principal groups of mankind would not be of any great utility. But it was also soon recognized that even the principal races of man were not in all respects far enough distant to give alone a sound basis for classification. It was then that recourse was had to mathematical procedure. By taking all the available indices on man regardless of racial subdivisions, ranges of indices could be obtained which applied to the human family as a whole; and these ranges gave certain averages as well as minima and maxima which could serve as bases of mathematical classification. From an insufficiency of data however and from other causes, there arose numerous individual differences of views among working anthropologists as to exactly where to establish the boundaries of the subdivisions of the various indices, and also as to the best terms for the different subdivisions, which gave rise to a considerable confusion.

To-day anthropology has ceased to regard the grouping and naming of the indices in the somewhat fetishistic light in which it looked upon them before. The arithmetic and graphic presentation of the distribution of each index has become the essential procedure in all anthropometric work, and divisions with terms, which in the nature of things must always retain something of the arbitrary, are now employed more for convenience than of necessity. Still, the classification of the various indices and its terminology are useful, and some day will doubtless become subject to proper international agreements.

In these pages no attempt will be made to treat the subject of anthropometric indices historically, or to give their different classifications. For these the student is referred to Broca's *Instructions*, Topinard's *Éléments d'Anthropologie générale*,[1] Martin's *Lehrbuch*, and similar publications in other languages. What will here be given with few exceptions are the most widely accepted and most frequently used indices, together with best known nomenclatures.

There is no limit to other legitimate indices, as there is none to possible measurements; and any index, as any measurement, may assume more or less of anthropological value if obtained on sufficiently large series and groups of individuals or specimens.

HEAD AND SKULL.

Cephalic (and Cranial) Index—$\frac{B \times 100}{L}$—
Dolichocephaly.....up to 74.9
Mesocephaly............75–79.9
Brachycephaly...........80 and above.

(On the skull the index is approximately 2 points lower than that on the head.)[2]

Mean Height Index (Cephalic and Cranial)—$\frac{\text{H[3]} \times 100}{\text{Mean of L} + \text{B}}$

Height—Length Index—$\frac{H \times 100}{L}$—(of limited use).

Height—Breadth Index—$\frac{H \times 100}{B}$—(of limited use).

Cephalic (or Cranial) Module—$\frac{\text{L} + \text{B} + \text{H[3]}}{3}$

Physiognomic Index (on Head)—$\frac{\text{Diameter bizygomatic maximum} \times 100}{\text{Menton-Hair line diameter}}$

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[1] Which is particularly rich in historic notes, p. 364 *et seq.*

[2] See on this point Topinard's *Éléments etc.*, 373; also Duckworth (W. L. H.)—*J. Anat.*, Lond., 1917, LI, 167–179.

[3] Height, on head, from line connecting floor of auditory meatus to bregma; on skull, basion-bregma. Not directly comparable.

Facial Index (on Head)— $\frac{\text{Menton-nasion height} \times 100}{\text{Diameter bizygomatic maximum}}$

Facial Index, Total (on Skull)— $\frac{\text{Menton-nasion height} \times 100}{\text{Diameter bizygomatic maximum}}$

Facial Index, Upper (on Skull)— $\frac{\text{Alveolar pt.—nasion height} \times 100}{\text{Diameter bizygomatic maximum}}$

Facial Angle—Angle between basion-alveolar point and alveolar point-nasion lines.

Alveolar Angle—Angle between basion-alveolar point and alveolar point-subnasal point lines.

Orbital Index— $\frac{\text{Mean height of orbits} \times 100}{\text{Mean Breadth}}$ —

Microseme	up to 82.9
Mesoseme	83–88.9
Megaseme	89 and above.

Nasal Index: (on Head)— $\frac{B \times 100}{L}$ —

Leptorhinic	up to 69.9
Mesorhinic	70–84.9
Platyrhinic	85 and above.

Nasal Index: (on Skull)— $\frac{B \times 100}{L}$ —

Leptorhinic	up to 47.9
Mesorhinic	48–52.9
Platyrhinic	53 and above.

Ear Index: (on Head)— $\frac{B \times 100}{L}$

Palatal Index— $\frac{B \times 100}{L}$ —

Dolichouranic	below 110
Mesuranic	110–115
Brachyuranic	above 115.

Dental Index— $\frac{\text{Dental length}^{1} \times 100}{\text{Basion-nasion diameter}}$ —

Microdont	up to 41.9
Mesodont	42–44
Megadont	above 44.

BODY.

Sitting Height Index— $\frac{HS \times 100}{\text{Stature}}$

Height-Weight Index— $\frac{\text{Weight in grams}}{\text{Stature in centimeters}}$

Chest Index— $\frac{\text{Diam. antero-posterior (mean) at nipple height} \times 100^{2}}{\text{Diam. lateral (mean) at same level}}$

Pelvis—Shoulder Index— $\frac{\text{Maximum external breadth of pelvis} \times 100^{3}}{\text{Breadth of shoulders}}$

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[1] Distance *in situ* between most anterior point on 1st premolar and most posterior point on normal 3rd molar.

[2] In female at the upper level of the 4th chondrosternal articulation.

[3] Between outer lips of iliac crests.

Hand Index— $\frac{B \times 100}{L}$[1] **Foot Index**— $\frac{B \times 100}{L}$[1]

SKELETAL PARTS.

Pelvis: Total Index— $\frac{\text{Mean max. height of ossa innom.} \times 100}{\text{Greatest external breadth of pelvis}}$[2]

Pelvic or Brim Index—

$\frac{\text{Antero-post. diam. of superior strait} \times 100}{\text{Greatest transverse breadth of the strait}}$ —
Dolichopellic ....above 95
Mesatipellic 95–90
Platypellic ......below 90.

Sacrum— $\frac{B \times 100}{L}$ —
Dolichohieric ....up to 100
Platyhieric ....above 100

Radio-Humeral Index— $\frac{\text{Max. L of radius} \times 100}{\text{Max. L of humerus}}$ —
Brachykerkik....less than 75
Mesatikerkik.............75–80
Dolichokerkik......above 80.

Tibio-Femoral Index— $\frac{\text{L of tibia (less spine)} \times 100}{\text{Bicondylar L of femur}}$ —
Brachycnemic ....less than 83
Dolichocnemic ...83 and over.

Humero-Femoral Index— $\frac{\text{Max. L of humerus} \times 100}{\text{Bicondylar L of femur}}$

Intermembrae Index— $\frac{\text{L of radius} + \text{L of humerus} \times 100}{\text{Standard L of tibia} + \text{Bicondylar L of femur}}$

Platybrachic Index— $\frac{\text{Diameter minor of shaft of humerus at middle} \times 100}{\text{Diameter major}}$

Platycnaemic Index— $\frac{\text{Diameter minimum of shaft of tibia at middle} \times 100}{\text{Diam. maximum}}$

Platymesic Index— $\frac{\text{Diam. minimum at upper flattening of femur} \times 100}{\text{Diam. maximum}}$

Scapular Index (new)— $\frac{\text{B, glenoid point to spine point} \times 100}{\text{L, glenoid point to inferior angle}}$

Scapular Index: Total— $\frac{\text{B, m. of outer border of glenoid fossa to spine point} \times 100}{\text{L, from superior to inferior angle}}$

Infraspinosus Index— $\frac{B \times 100}{\text{L, from spine point to inferior angle}}$

Sternal Index— $\frac{\text{Greatest B of body} \times 100}{\text{Total L with manubrium but without xiphoid}}$

For other indices see text under the individual bones.

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[1] For definition of measurements see text.

[2] Between outer lips of iliac crests.

INDEX TABLES.

To lighten the exacting and tedious work of calculating the indices, we now have a number of printed "Tables." The best of these are those of Carl M. Fürst (*Index-Tabellen; 4°, Jena, 1902*); but even these are not sufficient for all occasions and much work has to be done by each student himself. When a large number of indices are to be calculated for which no ready-made tables can be found, it pays to make such tables.

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